



IMPROVING LOGISTICS FOR PERISHABLE AGRICULTURAL PRODUCTS IN THE PEOPLE'S REPUBLIC OF CHINA

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Co-publication of the Asian Development Bank
and the Development Research Center of the State Council
of the People's Republic of China





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Foreword

The People's Republic of China (PRC) is among the world's largest producers and consumers of agricultural products. The PRC's agricultural logistics system needs to move produce efficiently and safely from production areas to the tables of more than 1 billion consumers. I am pleased to present this report, *Improving Logistics for Perishable Agricultural Products in the People's Republic of China*, which is prepared by an Asian Development Bank-financed technical assistance project implemented between 2012 and 2015. Although this report is prepared primarily for agriculture policy makers in the PRC, we believe lessons from the analysis and research offer important guidance for other developing economies in the Asia and Pacific region. Agricultural logistics is an extremely important issue: in many economies, a large share of the labor force is engaged in farming, and consumers are demanding efficient distribution of quality food products.

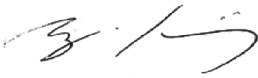
Although the relative contribution of the agriculture sector to gross domestic product is shrinking in developing economies in Asia and the Pacific, it continues to account for a large share of total employment. Yet, labor productivity is much lower in the agriculture sector, resulting in much lower incomes particularly in rural areas. Improvements in agricultural logistics offer a way to reduce these differences. They also offer a way to reduce the enormous waste of agricultural products. In the absence of cold storage and other basic logistics facilities, 30% of perishable agricultural products in the PRC are estimated to be lost before reaching consumers.

The report is based on findings from an assessment of the strengths and weaknesses of the PRC's agricultural logistics system; a business process analysis for vegetables and pork supply chains in Shandong Province, which provides an empirical understanding of the agricultural supply chain in that province and, by inference, in the PRC more generally; and the experiences of other economies that have modernized their agricultural logistics systems.

The recommendations address two key aspects of the agricultural logistics: the flow of products and information in the agricultural product supply

chain, and the organization of market participants and infrastructure. For the short to medium term, it is recommended to improve the flow of products by enhancing food labeling, packaging, and grading, and by facilitating physical handling, storage, and transportation of products. In the longer term, it is important that producers and distributors change the way in which they are organized to facilitate a larger scale of operations supported by infrastructure, technology, and capacity development. The recommended strategies are expected to result in logistical efficiency gains, and more broadly in improvements in the performance of agricultural markets in the PRC.

A solid foundation of knowledge and sharing of good practices will facilitate real impact and change in policy making. I am confident that this report will add to the understanding of the development of an agricultural logistics sector and will help to catalyze actions to strengthen the sector in the PRC and beyond.



Ayumi Konishi
Director General
East Asia Department
Asian Development Bank

Foreword

As economic development in the People's Republic of China (PRC) enters a new normal, the standard of living and the consumption structure in the PRC has rapidly changed, generating a range of new demands on the production, circulation, and safety of perishable agricultural products. As the crucial link between production and markets, a modernized agricultural logistics network is key to accelerating the modernization of agriculture, improving the efficiency of agricultural production, and upgrading the market for agricultural products. Moreover, it better satisfies the growing demand for higher-quality food, stabilizes the market for agricultural products, and improves the efficiency of distribution.

Recognizing the importance of establishing a modern logistics system for agricultural products, in recent years the PRC government has issued a series of regulations and policies. Nevertheless, agricultural logistics remain underdeveloped and have not seen fundamental improvements. The distribution of agricultural products continues to be inefficient and behind the times, leading to excessive spoilage and driving up logistics costs. This has affected both the supply of agricultural products and the stability of the market, compromising the potential positive effects of government policies that aim to boost agricultural development and increase farmers' yields. Therefore, the PRC government has prioritized accelerating the establishment of a more efficient and modernized agricultural logistics system.

Against this backdrop, the Logistics System Development for Agricultural Products—a joint technical assistance program between the Development Research Center of the State Council (DRC) of the PRC and the Asian Development Bank (ADB)—is significant in terms of both policy and practice. For the DRC, the project is of great importance, and we decided to establish a research team consisting of our own experts and others from the RAND Corporation, a United States-based nonprofit policy think tank. Over the course of about 2 years, the research team carried out substantial field studies, convened many high-level panel discussions, and conducted in-depth and systematic research into the approaches, modes, and priorities required to develop a modern agricultural logistics system in the PRC.

The research team has proposed practical and feasible policy advice to guide the decisions of the PRC government in promoting consumption, stabilizing the market, and improving agricultural policies. The team has also provided suggestions to government departments on agricultural logistics development planning, and on policy support.

As a PRC government policy research and consulting institution, the DRC is ranked top in the “Chinese Think Tank Influence Report,” which was initiated in 2014. Through its own efforts and development, the DRC is ushering in a period of historic opportunity. It is my sincere hope that the DRC will further its cooperation and exchanges with ADB, as well as other international organizations and think tanks. This will ensure that the DRC produces research and consultation of the highest caliber to better serve the PRC’s reform and opening-up, and economic and social development.

A stylized calligraphy signature in black ink, consisting of two characters: '李' (Li) and '伟' (Wei).

Li Wei

President

Development Research Center of the State Council

People's Republic of China

Acknowledgments

This report summarizes the research and policy recommendations resulting from the Asian Development Bank (ADB) technical assistance project Logistics System Development for Agricultural Products in the People's Republic of China (PRC). The Development Research Center of the State Council (DRC) of the PRC served as the executing agency for the project. DRC President Li Wei and former Vice-President Jun Han provided project leadership.

For ADB, Fei Yu, senior economist, East Asia Department, was the task manager of the project and provided overall supervision and coordination. Ayumi Konishi, director general of the East Asia Department, and Qingfeng Zhang, director of Environment, Agriculture and Natural Resources Division of ADB, provided strategic guidance and support.

A collaborative team of researchers from the RAND Corporation and the DRC conducted the research and drafted the report. Yun Kang led the RAND team, including Alexander Rothenberg, Kun Gu, and Zhimin Mao. Wang Wei, director general at the Institute of Market Economy in the DRC, led the DRC team and, through her intellectual leadership, helped to shape the research. The DRC team also included Liu Tao, Wang Qing, Li Bu, and Qi Yunlan. Each contributed significantly to the project.

Debra Knopman and Keith Crane of the RAND Corporation; Ren Xingzhou, former director general of the Institute of Market Economy in the DRC; and Sun Lanlan, former director general, Department of International Cooperation in the DRC, provided management oversight and review throughout the project. Director General Cheng Guoqiang, Deputy Director Jiang Xiheng, and Division Chief Feng Wei, Department of International Cooperation in the DRC, provided strong support in terms of organization, coordination, and oversight responsibilities and also provided support and help in terms of project finance and research organization.

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and Reform Commission; Zhang Xingwang, Ministry of Agriculture; Xu Min and Li Danghui, Ministry of Commerce; Xing Jiqui, Ministry of Finance; Liu Zhanshan, Ministry of Transport; Xu Xingqing, Standardization Administration; and Zhang Dejin, Beijing Municipal Commission of Commerce. Li Yimin of the Commission of Commerce of Shandong Province provided substantial assistance in planning and coordinating field trips and surveys in the PRC.

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Abbreviations

ADB	Asian Development Bank
BPA	business process analysis
CSF	cold storage facility
DRC	Development Research Center of the State Council of the People's Republic of China
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
ha	hectare
JA	Central Union of Agricultural Co-Operatives
kg	kilogram
km	kilometer
MAFF	Ministry of Agriculture, Forestry and Fisheries of Japan
MOA	Ministry of Agriculture of the People's Republic of China
MOFCOM	Ministry of Commerce of the People's Republic of China
NDRC	National Development and Reform Commission
PRC	People's Republic of China
US	United States
USDA	United States Department of Agriculture

Executive Summary

The People's Republic of China (PRC) is the world's largest producer and consumer of agricultural products, and its agricultural logistics system is responsible for moving food products from farms to the tables of more than 1 billion consumers. Although the agricultural logistics system has improved in recent years, it remains less efficient than systems in economies with higher per capita incomes. Spoilage rates for food products have been estimated at 30% in the PRC, whereas in developed economies, spoilage rates are typically less than 3%. Logistics costs account for close to 20% of the PRC's gross domestic product, compared with 10% or even less in economies with the most efficient logistics systems.

This report provides policy options for promoting efficiency improvements in agricultural logistics in the PRC, based on an assessment of the strengths and weaknesses of the PRC's agricultural logistics system, a business process analysis (BPA) of the supply and distribution chain for lettuce and pork originating in Shandong Province, and the experiences of others that have modernized their agricultural logistics systems.

Challenges in the People's Republic of China's Agricultural Logistics System

Five key areas constrain the efficient operation of agricultural logistics: scale of operation, packaging standards, product grading and food safety, market information systems, and cold chain technology:

- **Scale of operation.** The PRC has about 200 million farm households, each of which typically operates a very small plot of land. Despite the recent rapid growth in agricultural production, the small scale of the PRC's farms imposes a key constraint on the efficiency of the traditional food system. Small farms can be inefficient because the households operating these farms are often unable to make investments in capital-intensive equipment that would raise agricultural productivity.

- **Packaging standards.** Proper packaging is important for agricultural logistics because it makes it easier to handle products as they are transported between markets and collection points. Along the so-called first mile of agricultural logistics, in which food moves from farms to local wholesale markets, farm products are seldom packaged at all. If they are, inferior packaging methods are used. This leads to increased spoilage, damage, and potential food safety hazards. In addition to shortfalls in the use of modern packaging methods, there are no widely adopted packaging standards for fruits, vegetables, and meat products. Different packaging standards are used at different points along the supply chain, and this lack of standards interrupts the flow of goods from one point in the supply chain to another as goods are unloaded and repackaged.
- **Product grading and food safety.** In the PRC's traditional food system, many products are distributed without quality grades or food safety labels. An important role of government in any food system is to inspect food, determine its quality and guarantee its safety, and to provide that information to the public. Grading food products and inspecting food for safety is difficult in the PRC because the distribution of agricultural products is highly fragmented, involving many different individual producers, traders, brokers, wholesalers, and retailers.
- **Market information systems at wholesale markets.** Roughly 70% of the fruits, vegetables, and meat products produced in the PRC are traded at wholesale markets. One important function of these markets is to create the conditions for price transparency, in which the market successfully aggregates price information from a large volume of transactions and disseminates that information to buyers and sellers. The provision of market information has been increasing over time, but there are still many shortfalls to address. Currently, only less than 20% of wholesale markets report price information to the PRC's Ministry of Agriculture. Many wholesale markets currently lack the ability to collect and distribute market information.
- **Cold chain technology.** Traditional storage and transportation methods are still the norm throughout the PRC's traditional food system. Traditional cooling methods, such as ice and blankets for insulation, tend to exacerbate spoilage rates, particularly if they are used to haul food over long distances. Cold chain logistics are still in their infancy in the PRC. Only 7% of fruits and vegetables, 17% of meat products, and 25% of fish and shellfish are distributed using cold chain

logistics technologies. The capacity of refrigerated warehouses and vehicles still remains very low.

Business Process Analysis

The research team conducted a field-based BPA of two products—lettuce and pork—that are important food products for consumers in the PRC and representative of logistics challenges in the traditional food system. The BPA involved structured interviews with market participants at different stages of the logistics process.

The main findings from the BPA for lettuce are as follows:

- Lettuce is generally handled at ambient temperature and is neither pre-cooled at harvest sites nor refrigerated throughout the entire distribution process. As a result, the entire logistics process must be completed within 24 hours to guarantee freshness and quality.
- Although the largest portion of losses and waste takes place at retail markets, significant losses and waste also occur throughout the distribution chain because of water evaporation and damage from handling. Proper packaging and cooling operations, used throughout the entire distribution process, would reduce spoilage rates considerably.
- Spoilage and agricultural logistics costs for lettuce are both substantial. We estimate that spoilage rates in the PRC are between 21%–35% for lettuce, compared with approximately 7% in the United States (US). Given these spoilage rates and observed price differences between locations in the supply chain, we estimate the magnitude of logistics costs. Moving lettuce between producer and consumer wholesale markets (that is, a wholesale market in or near a major consumption center) leads to a 50%–60% increase in prices, with more than 70% of that caused by logistics costs. Reducing logistics costs could lead to significant gains for producers and consumers, depending on how changes in logistics costs affect the structure of the market.

The main findings from the BPA for low-end, traditionally produced pork are as follows:

- In the traditional, low-end pork production and distribution system, small-scale slaughtering firms are the key market participants. These

small enterprises provide traditional carcass meat at varying levels of quality. This contrasts with higher-end systems, in which large, well-equipped enterprises provide chilled meat of consistent quality.

- In the traditional system, pork is distributed mainly through wholesale markets or directly to farm produce markets in the city. Throughout the logistics processes, which consist of slaughtering, wholesaling, and retailing, pork meat is kept at room temperature, increasing the possibility of contamination.

To supplement the quantitative information collected in the field-based BPA, we also conducted structured, qualitative surveys of experts in the private and public sectors in the field of agricultural logistics. The main findings from the expert interviews are as follows:

- Cold chain technology is used at a much higher rate in the modern, farm-to-supermarket distribution system than in the traditional food system, which is oriented toward wholesale markets. Big gaps in technology, equipment, and facilities exist between these two systems.
- Consumer demand for more cold chain technology in the traditional food system is very strong, and existing technologies are adequate for meeting these demands. However, inadequate human resources, existing laws and regulations, the policy system, and the small size and scale of producers are all holding back a greater penetration of cold chain technologies.

International Experience Study

We selected Japan; Taipei,China; and the US for having demonstrated successes in making advancements in the agricultural logistics systems, as shown by their low spoilage rates. Japan and Taipei,China have a very strong presence of small-scale farming and rely heavily on farmers' organizations to coordinate production and distribution. They are also very similar to the PRC in terms of the important role of the wholesale and retail markets. In this part of the study, we found the following:

- **Scale of operation.** The experiences of Japan and Taipei,China have shown that modern logistics can be achieved in a small-scale production environment if the government plays a role in promoting and enhancing the development of farmers' organizations. Both Japan and Taipei,China have large, centralized cooperative systems with

hierarchically structured organizations across the geographic levels. The government significantly influenced the establishment of farmers' organizations. Beyond establishment, government intervened in the management and operation of farmers' organizations.

- **Packaging standards.** In comparator economies where farmers' organizations play an important role in organizing production and distribution, such as Taipei,China and Japan, the organization plays a decisive role in selecting the packaging standard and enforcing its adoption. The participation of supply chains is critical in driving the adoption, as done in these areas where products are accepted at wholesale markets and retail markets only if they are shipped with proper labeling and packaging that are marked with key information about the origin of the produce and product grade.
- **Product grading and food safety.** In advanced economies, the media have played a significant role in providing impetus for national legislation on food safety. National legislation on food safety was enacted in response to news about safety violations. In the US, many industry associations are directly involved in the politics of determining and changing meat grades. These associations are also instrumental in the implementation of the grading system. In the beginning, when there was no national grading system, the industry associations had used their own systems to differentiate the quality of beef, but government harmonized and standardized these systems.
- **Market information systems at wholesale markets.** One of the most important functions of markets is to create the conditions for price transparency, in which buyers and sellers are fully informed of prices at the marketplace. Governments can actively drive the development and management of market information systems at wholesale markets. Japan and Taipei,China both operate market information systems to promote efficient marketing and raise farm incomes. In both, agricultural market information is a government service that receives regular government funding. In Taipei,China, the government created wholesale market reforms that included the establishment of a market information system, and the government agency was directly involved in the design and implementation of this system.
- **Cold chain technology.** Governments' approaches to developing cold chain distribution differed widely among the comparators studied. In the US, the government allowed the commercial market to drive the

adoption of cold chain distribution. In contrast, in Taipei, China and Japan, the governments intervened actively to promote usage of cold chain technologies, using programs that included measures such as mandates, standards for building refrigeration capacity, and funding research and education. Experiences also suggest that government programs to promote cold chain usage tend to be implemented at key places of trade where the government already intervenes in operations, such as wholesale markets.

Policy Recommendations

This report highlights several areas in which policy changes can promote efficiency improvements in agricultural logistics in the PRC. We present recommended policy actions to the PRC government to consider when investing in the agricultural logistics system. We did not conduct a full cost-benefit analysis of policy recommendations as this is beyond the scope of this study.

The policy recommendations is structured into two groups: recommendations that focus on improving the flow of products and information in the agricultural product supply chain, and considerations for enhancing organization of market participants and infrastructure.

Measures to improve the flow of products facilitate physical handling, storage, and transportation of products. Improving the flow of information entails making accurate and timely market data available to the market participants. These policy actions are considered short to medium term and are given higher priority because they can improve the efficiency and safety of the logistics system more quickly.

The second set of recommendations refers to changing the way in which producers and distributors are organized and helping them develop their capabilities. These strategies can take much longer to successfully implement and might not necessarily result in immediate improvements in logistics performance. However, they will be key sources of productivity and safety improvements for the PRC's traditional food system in the long term.

The short- to medium-term actions address three key areas of the logistics system discussed earlier: packaging standards, product grading and food safety, and market information systems. The long-term actions address issues related to the scale of operations, cold chain technology, and logistics infrastructure in the broader sense.

Uniform Packaging Standards

We recommend the following steps to improve the enforcement and implementation of the existing national product packaging standards and enhance vertical coordination:

- **Implement national product standards using the network of wholesale markets.** Beginning with the largest and most strategically positioned wholesale markets, policy makers should start to require coordination and uniformity of packaging standards that comply with existing national regulations.
- **Use industry associations in developing and promoting standard packaging.** Subject matter knowledge and experience possessed by various industry groups specializing in areas such as transport unit standards (e.g., containers and pallets) and packaging technology, should be leveraged in setting up and implementing packaging standards.
- **Conduct information campaigns about proper packaging for farmers.** Beginning with the most important products, the government should provide market players with detailed instructions about appropriate packaging methods. This education would speed up the adoption of uniform standards throughout the system.
- **Consolidate and clarify enforcement responsibilities.** The State Council should designate a single decision-making body to enforce product packaging standards at each stage of the production and distribution process.

Product Grading and Food Safety

We believe that the following steps should be taken to implement and enforce a system of grading, labeling, and food safety inspection:

- **Consolidate inspection responsibilities.** The State Council should consolidate the responsibilities for inspection and grading of food products in a single decision-making body that should be responsible for grading, labeling, and food safety inspections.
- **Expand safety inspection and grading along the supply chain.** The system of inspection should try to reach out beyond wholesale markets and into the first mile of the agricultural logistics process.

- **Strengthen traceability systems for food products.** For the most perishable and potentially dangerous agricultural products, the government should subsidize the adoption of traceability systems so that products can be traced back to their source.
- **Encourage the media to publicize food safety infringement.** Independent media should be used to spread information about public health concerns. Food safety outbreaks need to be brought to the public's attention as soon as possible.
- **Develop stronger legal measures for enforcing food safety.** Recent efforts to enforce standards and punish local government officials for food safety infringements should be extended to other participants, including food production companies.

Market Information Systems

To build a market information system that is integral to improving the efficiency of the PRC's agricultural logistics system, we recommend the following actions:

- **Build the market information system by starting with disseminating data from the largest and most important wholesale markets.** Many wholesale markets in the PRC currently collect and record information on market transactions and prices. Government could reach out to these large markets and establish systems for sharing data.
- **Enhance the functionalities of the market information system.** Building the right functionalities in the market information system, such as localized price data and demand forecast, is essential for meeting the requirements of the system's end users.
- **Enhance market information delivery to farmers.** Previous attempts by governments showed success in using mobile phones to provide easy access not only to price data but also information on new agricultural technologies, product information, and agriculture policies.
- **Incentivize market participants to create a central, unified electronic marketplace.** An extensive and integrated market information system becomes the basis for electronic marketplaces that establish networks of trading partners across regions and connect

them together. This helps producers connect to buyers beyond their traditional reach.

- **Designate a single government agency to be responsible for system construction and management.** Having one government agency managing the information system enables system and data standardization; simplifies day-to-day data collection, release, and analysis operations; and reduces the total system cost.

Long-Term Policy Considerations

The long-term policy-making considerations include increasing the scale of operation in production by consolidating farmers' cooperatives that can organize larger-scale marketing and logistics activities, building strong third-party logistics enterprises that can consolidate the supply and marketing activities for producers and offer a wide variety of agribusiness services to producers, and vertically integrating the producers with retailers.

Wholesale markets can be better integrated by creating a centralized regulatory framework to address their establishment and operation. Governments can control the establishment of wholesale markets and help rationalize the number of wholesale markets and their location.

In addition, we recommend several policy actions for developing the logistics infrastructure in general: increasing the refrigerated storage capacity at wholesale markets that transact high volumes of short shelf-life products; and supporting for long-distance, high-volume transportation of agricultural products, such as trains designed specifically for agricultural product containers.

CHAPTER 1

Introduction

Following decades of rapid economic development, population growth, and improved living standards, the People's Republic of China (PRC) has emerged as the world's largest producer and consumer of perishable agricultural products (United States International Trade Commission 2011).¹ As the PRC's consumers grow wealthier, they will continue to increase their demand for food products, particularly meat products. For example, per capita consumption of pork is projected to rise by nearly 17% over the next 10 years (Hansen and Gale 2014). As a result, the PRC's agricultural logistics system, which is responsible for transporting goods safely and efficiently from production centers to the tables of more than 1 billion consumers (United States International Trade Commission 2011), is expected to handle an increasingly large volume and variety of products in the future.

Although the PRC's agricultural logistics system has made improvements in recent years, it remains less efficient than systems in economies with higher per capita incomes. Logistics costs still account for close to 20% of the PRC's gross domestic product (GDP), compared with 10% or even less in economies with the most efficient logistics systems. Continued logistical inefficiencies are of particular concern for agriculture, given the time constraints and care required for storing and transporting perishable products. Inefficiencies in agricultural logistics can contribute to low profits for farmers, lead to higher and more volatile food prices, degrade food quality, and threaten the safety of food supplies for consumers.

Logistical inefficiencies also create shipping delays that increase the costs of doing business and hinder market opportunities. These delays, combined with shortfalls in temperature-controlled transportation and storage capacity, increase the likelihood of spoilage of perishable products. Approximately 30% of the volume of food produced in the PRC spoils as it makes its way to consumers. By comparison, spoilage rates in the most

¹ This claim is based on the total value of farm products produced and consumed domestically. For instance, in 2007, the total value of farm production in the PRC was \$537 billion, compared with \$329 billion in the United States (United States International Trade Commission 2011).

efficient agricultural logistics systems worldwide range from 2% to 3%. Such inefficiency, coupled with the PRC consumers' growing demand for higher-quality food, creates a need for faster delivery and better storage and transportation methods such as cold chain technology.

The PRC needs to improve agricultural logistics if it is to continue to raise living standards and promote growth in agriculture and the agribusiness industry. Beyond connecting farmers to markets, strategies to improve agricultural logistics are likely to have positive spillover benefits for improving logistics in other sectors, further contributing to the PRC's economic growth and development.

In 2009, recognizing the need to modernize its agricultural logistics system, the State Council of the People's Republic of China issued a plan to guide development of the logistics industry. In June 2010, as part of the effort to implement the plan, the National Development and Reform Commission (NDRC) prepared a five-year development plan (for 2010–2015) for cold chain logistics for agricultural products. Given the current size and expected future agricultural needs of the PRC, the task of achieving greater efficiency in logistics for the agriculture sector is a significant challenge, and it will require not only government support but also strong private sector efforts. The government's role will be to support business-led initiatives through the provision of an enabling policy, regulatory, and institutional environment, and public infrastructure components of the supply chain.

In 2011, the government of the PRC requested the Asian Development Bank (ADB) to provide policy and advisory technical assistance to improve agricultural logistics in the PRC. In consultation with the Development Research Center of the State Council (DRC), ADB agreed to provide assistance and launched the project in March 2013 with the objective of providing recommendations on key policy and regulatory changes that could lead to improvements in the logistics system for agricultural products in the PRC.

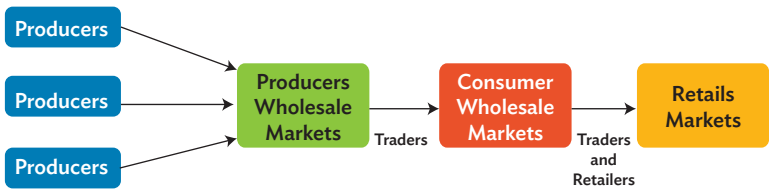
This report highlights several areas in which policy changes can promote efficiency improvements in agricultural logistics in the PRC. Although a full cost–benefit analysis of policy recommendations is beyond the scope of this study, we hope that this report will identify several areas in which the government might consider taking policy actions. It is the final deliverable submitted for TA 8157-PRC: Logistics System Development for Agricultural Products (ADB 2012). This final report stems from research and analysis that researchers from the RAND Corporation and the Institute of Market Economy of the DRC conducted between March 2013 and October 2014.

The research effort consisted of three key tasks: to understand the current landscape and assess the strengths and weaknesses of the PRC’s agricultural logistics system; to gain an empirical understanding of the characteristics of the PRC’s agricultural supply chain and some of the challenges it faces, and conduct a business process analysis (BPA) of the supply and distribution chain for lettuce and pork originating in Shandong Province; and to draw lessons for the PRC from other comparators’ experiences and investigate the experiences of others that have modernized their agricultural logistics systems. In this report, we synthesize the findings from each of these three tasks and identify various policy options for the PRC that the government could use to improve the efficiency of agricultural logistics. This report’s intended audiences include policy makers in the PRC and others interested in developments in agriculture in the PRC and agricultural economics and logistics more generally.

The People’s Republic of China’s Traditional Agricultural Logistics System

An agricultural logistics system connects producers, who grow and raise food products, to consumers. The PRC’s agricultural logistics system is a large network consisting of individuals and organizations that coordinates the harvesting, collection, transportation, inspection, and distribution of food products. Although distribution methods vary, in the traditional food system, the vast majority of agricultural products produced and sold in the PRC are distributed through a logistics system similar to that shown in Figure 1.1. A large number of farmers (producers) who are scattered throughout rural areas grow fruits and vegetables. Traders who run businesses of varying types and sizes bring food products from farmers to producer wholesale

Figure 1.1: Representative Flow of Goods in Agricultural Logistics in the People’s Republic of China



Source: RAND Corporation and Development Research Center of the State Council analysis.

markets, where they are sold.² At these wholesale markets, a different set of traders purchases those products and transports them to consumer wholesale markets located closer to major consumption areas. Retailers or other traders move products from consumer wholesale markets to retail markets, where products are sold to consumers. Foods can pass through many wholesale markets before reaching their final destinations.

Wholesale markets serve as the link between small farmers and retail markets and play a central role in the PRC's traditional food system, helping to coordinate the flow of goods from producers to consumers. Without wholesale markets, the PRC's small farmers would have to sell goods directly to consumers or negotiate separately with individual retailers. With so many small farmers, transaction costs would increase dramatically, making it impossible for retailers to realize efficiency gains from economies of scale (Tollens 1997). Given the dominance of small farmers in the PRC's traditional food system and their expected continued presence, wholesale markets are expected to continue to play an important role in the PRC's traditional food system. Currently, more than 70% of agricultural products in the PRC are distributed through wholesale markets.

For an agricultural logistics system to be efficient, it needs to be vertically coordinated. When a logistics system is vertically coordinated, each stage of the supply chain (production, processing, inspection, transportation, and marketing) is streamlined and efficiently managed. Products pass from one stage to the next in a seamless, synchronized manner. In the PRC's traditional logistics system, the market is very diffuse; many different agents are involved throughout the stages of the logistics process. This creates several challenges for ensuring that the system is vertically coordinated: different agents can have different practices and technologies with respect to sorting, packaging, labeling, inspecting, and transporting food products. These differences can create delays and interrupt the seamless flow of goods.

One way to achieve vertical coordination in food markets is for a single firm to control all stages of production, distribution, and marketing processes for certain products. In the PRC's modern supermarkets and higher-end retail markets, including international retailers (e.g., Walmart, Carrefour, and Tesco) and the PRC operators (e.g., the Beijing Hualian Group), certain

² Farmers can bring their goods to producer wholesale markets on their own.

producers and retailers have become completely vertically integrated,³ often bypassing wholesale markets entirely. Although such forms of so-called direct distribution from producers to retailers are growing in size and importance, they still account for a relatively small percentage of the agricultural goods purchased. In this report, we focus on policy recommendations for the traditional distribution system, both because of its current size and because government policies can be more influential in promoting coordination and efficiency gains in this logistics system than in other systems.

Before making recommendations for policies to promote efficiency in the PRC's traditional logistics system, it is important to recognize several key trends in the production and consumption of agricultural products. These trends not only necessitate the efficiency improvements that are the object of our policy recommendations but also constrain the types of policy recommendations that are possible given the existing market circumstances. These trends are the following:

- The PRC has become the world's largest producer and consumer of agricultural products, and its agricultural logistics system is now required to handle an increasingly large volume and variety of products. With recent improvements in transportation and investment in infrastructure, regional agricultural markets in the PRC have become more tightly integrated, and cross-regional flows of agricultural products have been increasing over time.
- The ongoing process of urbanization in the PRC has resulted in a concentration of the population and food consumption markets in major urban areas. Agricultural production has become increasingly located in areas farther away from these cities. The separation of major production and consumption areas has strained the traditional agricultural logistics system, which now handles higher volumes, greater distances, and more complex networks of supply and demand than it has in the past. Historically, most vegetables and meats were produced close to major metropolitan areas, so distances from farm to consumer were less.
- As the PRC has become wealthier, individuals have not only increased their consumption of food; they have increased their demand for

³ Vertical integration refers to an organization having control over its supply chain either by owning the trading entities in the chain or by setting up contractual arrangements.

higher-quality and better value food products, substituting these foods for staple foods from the past. They are also demanding greater food safety; consumers from the PRC are insisting more and more strongly that food be unspoiled, untainted with bacteria or other pathogens that can make them ill, and unadulterated with chemicals or other substances. These demands are forcing the logistics system to innovate.

- The presence of small farmers dominates food production in the PRC. The small scale of production is a key constraint on agricultural logistics in the traditional food system. It necessitates the presence of wholesale markets as collection points for goods, and it requires traders and brokers to coordinate the flow of goods through the distribution system. Although larger farms, greater economies of scale, and fewer intermediaries could be beneficial for production and growth in the long term, unless there are major policy changes, this situation will probably not change in the foreseeable future.

Policy Goals

To improve agricultural logistics in the PRC's traditional food system, government policies and programs need to be designed to achieve the following overarching goals:

- **Improve efficiency and productivity.** Policies should improve the efficiency of the PRC's agricultural supply chain, reducing lead times,⁴ waste, and spoilage as goods flow throughout the system. Policy levers should be used to stimulate productivity growth for the PRC's farmers specifically and for the food system in general. Productivity improvements will ultimately reduce the system costs, including production, storage, transportation, and transaction costs. Productivity improvements will also increase the quality of food that reaches final consumers.
- **Ensure food safety.** Policies should provide for food safety regulations and standards that ensure a safe supply of food for consumers, with minimum quality standards met at every stage of the supply chain.

These two goals are the primary focus of our analysis and policy recommendations.

⁴ Lead time is defined as the time it takes for a logistics process or set of processes to be conducted.

Even with the best strategic policies, improvements in the PRC's agricultural logistics system will take a long time. Continuity and consistency of policies will be important to maintain so that actors in the system feel comfortable making the investments required to adapt to whatever new rules or policies are ultimately implemented. At the same time, it will also be important for the PRC to continually evaluate its agricultural logistics system, determining whether progress is being made and whether further improvements can take place.

Methodology

We used a variety of methods to conduct the analysis that forms the basis of our policy recommendations:

- **Literature review.** We reviewed existing academic journal articles and policy reports on agricultural logistics, both internationally and in the PRC specifically, as well as on the PRC's food system and the PRC's economy overall. We also reviewed relevant work in the literature on agricultural economics and industrial organization.
- **Interviews.** Through workshops held in offices and visits to the field, we conducted interviews with several different actors and authorities throughout the PRC's agricultural supply chain. This included interviews with farmers' cooperatives, traders, wholesalers, retailers, and business leaders. It also included interviews with government officials, trade association members, and leading academic experts.
- **Business process analysis.** We obtained firsthand knowledge of agricultural logistics in the PRC by studying real-life value chains involving major market participants. The study team chose lettuce produced by one of the largest farmers' cooperatives in Shandong Province, which is a major vegetable and meat production center in the PRC. The end point of the value chain—the consumption center—was chosen to be retail markets in Shanghai, which receives close to two-thirds of all the lettuce produced by the chosen producer. We also included in the scope of the study two wholesale markets between the production and consumption centers. We sent questionnaires seeking information on key logistics elements, including packaging, storage, transportation, lead time, losses, and cost, to participating individuals and organizations in the value chain. We also used a similar BPA to analyze a logistics chain for pork.

- **International experience studies.** We conducted a comparative policy analysis, focusing on the experiences of Japan; Taipei, China; and the United States—each of which uses a different policy approach to shape and transform agricultural logistics. By understanding the history and development of agricultural logistics in other economies—including key policies, their intended effects, and the outcomes—we identified various policy options available to the PRC and evaluated the context in which they would apply to the current PRC environment.

CHAPTER 2

Challenges in the Agricultural Logistics System of the People's Republic of China

In this chapter, we describe key challenges facing the traditional agricultural logistics system of the People's Republic of China (PRC). Although rapid advances are taking place in how agricultural products are distributed, particularly for the higher-end retail markets and supermarkets that serve the most affluent consumers, our report focuses on the traditional food system, which accounts for more than 70% of agricultural products purchased in the PRC today.⁵

We begin this chapter by describing barriers to efficiency along the so-called first mile of agricultural logistics in the PRC's traditional food system, the part in which food products are transported from farms to local wholesale markets. Next, we describe inefficiencies in distribution logistics as food products move through a series of wholesale markets, some located closer to production areas and some closer to consumption areas.

As we describe how food products pass through the traditional system, we highlight five key policy areas in which changes to the status quo could streamline logistics and improve outcomes: scale of operation, packaging standards, product quality (grading and food safety), market information systems, and cold chain technology.

Scale of Operation: The First Mile

The PRC has approximately 200 million farm households, producing food on an average of 2.5 hectares (ha) of land per farm household (Organisation for

⁵ For an overview of the rise of supermarkets in the PRC and other Asian economies and the role of local and foreign direct investment, see Reardon, Timmer, and Minten (2012).

Economic Co-Operation and Development 2005).⁶ Although small farms are common in Japan (roughly 2 ha per farm household) or Taipei, China (1 ha per farm household), the United States (US) has much larger farms, with an average of 187 ha per farm household. Despite rapid growth in agricultural production in the past several decades, the small scale and size of the PRC's farms impose a key constraint on the efficiency of the traditional food system. Small farms are labor intensive and can be inefficient because the households that operate these farms often cannot make the investments in capital-intensive equipment needed to raise agricultural productivity. The large number of small farmers in the traditional food system gives rise to a highly fragmented system of agricultural logistics in producer areas as goods are transported from farms to local wholesale markets—the so-called first mile of the logistics process.

The small scale of farms in the PRC is rooted in history. After the Communist Party achieved victory in the civil war in the PRC, party leaders took control of the farmland away from landlords, redistributed it to millions of peasant farmers, and began the process of collectivizing agricultural lands. Although recent measures to reform the landownership system and ease rural-to-urban migration restrictions might improve the situation, the PRC will likely have vast numbers of small farmers for the foreseeable future. The small size of household plots will remain a key constraint on efficiency for many years.

The recent growth of farmers' cooperatives in the PRC might be helpful for overcoming some of the challenges of small-scale production and fragmented logistics in producer areas. Cooperatives enable smallholder members to share production technologies and increase their scale and efficiency. Because cooperatives transact as a single entity in the marketplace, their size allows for increased market power that enables their members to obtain more favorable input and output prices. Cooperatives also play an integral role in coordinating agricultural logistics for member farmers, leading to more sophisticated methods of harvesting, sorting, and transportation. By the end of 2011, agricultural cooperatives registered in the PRC numbered more than 480,000. However, only about 20% of all farm households in the PRC (38 million) are members of agricultural cooperatives (State Administration for Industry and Commerce of the People's Republic of China 2012). Most cooperatives are small, and lack the ability to increase the scale of operation in production and distribution. Although the size of cooperatives and their importance are growing over

⁶ According to Ramankutty et al. (2008), the PRC has a total of 494 million ha of combined cropland and pastureland, an estimate that is consistent with figures on the total number of farm households and average hectares of land per household.

time, most farm households in the PRC are still not members of cooperatives, and they still rely on small-scale, inefficient methods of moving food products from their farms to local wholesale markets.

Another source of efficiency improvements in production logistics has been the increased presence of vertical integration between producers, processors, and retailers. In the US meat industry, several international food companies, such as Tyson Foods and Smithfield Foods, are attempting to establish vertically integrated supply chains in poultry and pork. These supply chains involve directly negotiated contracts with the farmers who raise livestock and have complete control of animals as they are transported from farms to processing facilities, slaughtered, packaged, and distributed to retailers. Because a single company controls production, packaging, and distribution, it has a strong incentive to reduce costs and raise efficiency internally. Those efficiency improvements will lead to higher profits. Similar trends are taking place in the PRC, which international retail food chains, such as Walmart and Carrefour, and international agricultural supply firms, such as Cargill, are spearheading.

An example of recent progress in vertical integration is the rice industry. Historically, most paddy rice in the PRC was processed at 100,000 township-level rice mills (McKee 2010). This decentralized rice milling was very labor intensive and relatively inefficient. However, in the past decade, rice milling in large mills owned by private corporations, including the PRC's China Oil and Food Corporation, has increased rapidly. These large mills can play an important role in coordinating the flow of goods from producers to consumers. By 2011, large mills were responsible for processing an estimated 20%–25% of the PRC's total rice output (Reardon et al. 2012).

Although vertically integrated supply chains can help improve efficiency, its effects on producer and consumer welfare are uncertain and difficult to establish without careful study. Vertical integration could have adverse effects on producer and consumer welfare because it typically creates market power that affects both the prices paid to producers for food products and the prices charged to consumers.⁷

⁷ For instance, Sexton and Lavoie (2001) argued that, in the United States, vertical integration in pork and poultry led to efficiency improvements that reduced consumer prices but had adverse effects on producer welfare.

Product Packaging

Modernization

Proper packaging is important for agricultural logistics because it makes handling products easier as they are transported between markets and collection points. It also reduces exposure to damage and loss at every stage of the distribution process. In the first mile of agricultural logistics, small farmers often harvest, collect, and transport food products to local wholesalers. In doing so, they tend not to use packaging, storing food products in the open air. When they do use packaging, it tends to be of low quality, often consisting of cardboard boxes, baskets, or plastic bags.

Increasingly, specialty food brokers have emerged to participate in the process of distributing food. These brokers drive from farm to farm, negotiating prices separately with each farmer they visit, collect produce, and transport it to local wholesalers. Over time, the number of specialized agricultural product brokers has increased dramatically, nearly tripling from 191,000 in 2006 to more than 500,000 in 2010 (Ministry of Agriculture of the People's Republic of China [MOA] 2009). These specialty brokers also use traditional technologies to store, package, and transport food. Specialty food brokers are a large class of intermediaries in the PRC and represent the most important means of transporting goods throughout the PRC's traditional food system. As we describe in Chapter 3, their labor-intensive, high-cost methods of moving goods create appreciable differences between producer and consumer prices.

Sometimes, improper packaging can create food safety hazards. For instance, farmers in Chongqing, Sichuan, were recently reported to be using fertilizer and pesticide bags to package grapefruits before the produce was transported to wholesale markets. Farmers were reluctant to pay for higher-quality cardboard boxes for grapefruits and simply recycled the pesticide bags they had used (Zhengxie Chongqing Qijiang District Committee 2014). Improper packaging increases product damage and spoilage rates and, because many packages are disposable, they cannot be recycled, creating waste and causing harm to the environment (China Federation of Logistics and Purchasing 2013).

Adopting Uniform Packaging Standards

In addition to shortfalls in the use of modern packaging methods, a major source of inefficiency in agricultural logistics for the PRC's traditional food

system is the absence of widely adopted packaging standards for fruits, vegetables, and meat products. Different packaging standards are used at different points along the supply chain. This lack of standards interrupts the flow of goods from one point in the supply chain to another as goods are unloaded and repackaged. Frequent handling and repackaging of agricultural products without proper packaging exacerbates damage to products, increases contamination risks, and adds to logistics costs.

Uniform packaging standards for agricultural products make the market for those products function more efficiently. Uniform packaging standards become the units of measurement that define the quantities of different products that are bought and sold. These units of measurement are reflected in the definition of prices of goods; coordinating units of measurement makes it possible for pricing information to pass seamlessly among market participants. For all of these reasons, standardized packaging is essential for ensuring an effective vertical coordination of the supply chain.

For many fruits and vegetables in the PRC, the adoption of packaging standards has taken place at a regional level (within provinces or prefectures), largely as a result of natural market forces. The problem is that, over time, different regions have adopted different packaging standards because, until very recently, different regional markets in the PRC were not tightly linked.

Historically, many commodities in the PRC were produced and consumed locally, using production and distribution networks that were entirely contained within provinces (or sometimes even within prefectures). Even after the economic reforms of the 1970s, the PRC's internal market remained very fragmented, and trade between provinces remained low. Poncet (2005) used data on internal trade flows to show that cross-provincial trade was heavily restricted in the 1990s, particularly for agricultural products. Local governments would often reduce trade flows to keep the prices of raw materials artificially low. This favors local food processing and manufacturers, which can charge higher prices for finished products (Bernstein and Lü 2000). Because of poor cross-regional transport infrastructure, ineffective food preservation technologies, and government-sponsored trade barriers, trading food across regions was difficult. With regional food markets that were typically oriented toward meeting the needs of local consumers, different packaging standards were allowed to develop and persist in different parts of the PRC (Tanaka and Busch 2003).

In the past 2 decades, the PRC's regions have become more tightly integrated. In April 2001, the PRC's State Council finally outlawed regional

and provincial blockades in market activities.⁸ Major transportation improvements, such as the National Trunk Highway System completed in 2007, have expanded the potential for cross-regional trade to take place (Faber 2014). This has allowed different regions to specialize in the production of certain goods and promoted more frequent trade between regions. As regional food markets become increasingly connected to one another, the different packaging standards used in different locations have created barriers to efficiency and disrupted the flow of goods.

Despite the recent increase in cross-regional trade, packaging standards remain uncoordinated and incoherent in the PRC. Although market forces promote and will eventually ensure the adoption of uniform packaging standards, there might be a role for government policy to accelerate the process. In particular, a strong national institution, working through the existing network of farmers' cooperatives, wholesale markets, and industry associations, should be able to encourage market participants to harmonize regional packaging standards and enforce the adoption of those standards.

The State Council has made several attempts to harmonize regional standards and codify them into national legislation. By 2007, the PRC had established a complete legislative framework for regulating the packaging of food products (State Council Information Office of the People's Republic of China 2007). Both the Standardization Law of the People's Republic of China, 1988, and the Food Safety Law, 2009, require market participants to package and label foods according to regulations. There are several departmental rules related to food production and more than 3,000 laws, rules, and regulations for agricultural products in the PRC (Song 2005).

Although there are currently many different national laws and regulations on packaging standards, these laws are not being effectively enforced. Enforcing standards is difficult because so many people are involved in the supply chain. Many different people are responsible for transporting goods from farms to wholesale markets and from wholesale markets to retail markets. Getting them to coordinate on a single standard for packaging remains a challenge unless market forces can send a clear signal of the value of standardization.

⁸ State Council of the People's Republic of China, date unknown, codified this.

Product Grading and Food Safety

In the PRC's traditional food system, many products are distributed without quality grades or food safety labels. An important role of government in any food system is to inspect food, determining its quality and guaranteeing its safety—and to provide that information to the public. Grading food products and inspecting food for safety is difficult in the PRC because the distribution of agricultural products is highly fragmented, involving many different individual producers, traders, brokers, wholesalers, and retailers. Because so many products change hands at so many different places, it is easy to adulterate food and mislabel it. This creates problems both for the smooth functioning of agricultural markets and for food safety and public health.

Accurately grading products enables product differentiation to take place, which helps improve the functioning of markets. Common knowledge about the quality of products for both producers and consumers is essential for conducting market transactions. Producers want consumers to be able to observe and distinguish the quality of their products from that of others because this distinction allows them to sell goods to the consumers they want to reach. For example, producers of high-quality fruits and vegetables need to be able to market their products to wealthier consumers who demand higher-quality food. Such producers have higher costs for delivering higher-quality products; they cannot breakeven if the prices they obtain on the market are too low. If low-quality producers can disguise their products as high quality, the high-quality producers suffer from lost revenue and market share. Consumers also suffer because they unknowingly purchase low-quality products. In the extreme, uncertainty and information asymmetry about quality can cause markets to completely unravel, resulting in no transactions taking place (Akerlof 1970). In addition to grading products to ensure that consumers can distinguish among different levels of quality, any food system must ensure that the products it delivers meet minimum safety and quality requirements.

Despite a large number of laws and regulations on food safety in the PRC, such as Product Quality Law of the People's Republic of China, 2000; Food Safety Law, 2009; and Food Safety Law, 2014, food safety remains a major issue. Although pesticide residues on farm produce have been reduced in recent years, over-the-limit pesticide residues have been detected frequently, especially in the southern regions of the PRC (which are more subject than others to pests and diseases) and for out-of-season farm produce.

Much of the problem originates from an inadequate system of inspection and enforcement of food safety. Most goods are not labeled or branded, making it difficult to determine where they are produced, or trace their flow through the food distribution system.⁹ Safety inspections take place for fresh produce only after the goods enter the wholesale markets. These markets (especially the markets close to production) lack quality inspection and quarantine equipment. According to statistics, only about one-third of rural markets are equipped with pesticide measurement devices, and equipment utilization remains low in many of them (MOA 2012b). For meat products, more than 80% of meat-packers that slaughter pigs still operate using semimechanized or manual production modes (MOA 2012a).¹⁰ Quality measurement and traceability technologies are seldom used. Because of the absence of regulated and systematic quality testing and a traceability system, particularly for meat products, adulteration is relatively easy, and guaranteeing food safety is difficult.

Market Information Systems at Wholesale Markets

Approximately 70% of the fruits, vegetables, and meat products produced in the PRC are traded through wholesale markets. Today, wholesale markets are established and operated without central oversight by the government. Currently, there is no national regulatory framework for setting up and operating wholesale markets; instead, local authorities regulate wholesale markets.

According to official statistics, there are now more than 3,600 wholesale markets, with a total trading volume of CNY1.4 trillion per year. Approximately 2,600 wholesale markets are centered in production areas, where they serve as clearinghouses for locally produced and harvested products. Many producer wholesale markets are set up specifically to buy and sell certain kinds of fruits and vegetables, while others serve as trading places

⁹ Increasingly, wholesale markets are adopting measures that are basic precursors to traceability, including requiring market participants to be registered, keeping detailed market records, and inspecting market transactions (Song et al. 2008). However, there is still considerable room for improvement.

¹⁰ In traditional slaughtering modes, particularly in developing economies and in rural areas, animals are often slaughtered, disemboweled, and sliced for consumption on the ground, typically in the same location. Spilling the contents of animal intestines on consumable meat increases the possibility for bacterial contamination (Animal Production and Health Commission for Asia and the Pacific 2008).

for many different crops. The remaining 1,000 wholesale markets serve as collection points in consumption areas, often in large cities (Ministry of Commerce of the People's Republic of China [MOFCOM] 2010b). At each of these nodes, products have to be unloaded, sorted, and traded, adding lead times and increasing the costs of distribution.

One of the most important functions of these wholesale markets is to create the conditions for price transparency because market information is aggregated from a large volume of individual transactions and disseminated to buyers and sellers. The absence of price transparency leads to inefficiency because buyers and sellers do not have the price signals they need to respond to shifts in supply and demand. The provision of market information has been increasing over time, both with efforts from markets themselves and from expansion in communication infrastructure, including the penetration of mobile phones. The Ministry of Agriculture of the People's Republic of China (MOA) and the Ministry of Commerce of the People's Republic of China (MOFCOM) have established market information systems that provide price information for the agricultural products reported by participating wholesale markets (MOA 2012c). Users can compare among wholesale markets and check the latest reports. In Appendix 1, we review the theoretical and empirical literature on how better access to market information can improve outcomes in agricultural markets and lead to welfare gains for both producers and consumers.

Many shortfalls still need to be addressed. Currently, less than 20% of wholesale markets report price information to MOA.¹¹ Many wholesale markets do not have the facilities to collect market information and distribute it to participants. At those markets, methods of transaction are outdated and inefficient. Prices tend to be determined separately for each transaction, using face-to-face negotiations settled in cash. Information about these transactions might never be recorded, collected, or displayed for other market participants to see. This impedes the formation of open and fair prices and the collection of price information (MOA 2009).

For the wholesale markets that do use information technologies to capture and display prices, the information they produce is made available only locally, rendering it difficult to use for purposes of cross-regional trade. The prices that the wholesale markets report often tend to be inaccurate because prices are collected and reported based on a product coding system that does not take into account product grading, varieties, and

¹¹ By the end of 2010, 748 wholesale markets were reporting prices to MOA, out of 4,093 agricultural product wholesale markets that cover an area of 2 ha or more (Zhou 2012).

specifications. As mentioned earlier, a standardized grading system is a key prerequisite for an effective market information system. Information about prices is not very useful unless quality is taken into account. Prices for high-quality food products are typically higher than those paid for lower-quality foods.

Although many wholesale markets have established electronic payment systems for monitoring and recording transactions in their own markets, transmitting the market data that those systems collect to a centralized collection and dissemination point is difficult. Currently, there is no unified management of market information systems for agricultural products. Wholesale markets report data to several government agencies, including MOA, MOFCOM, and the National Development and Reform Commission (NDRC). These different agencies have different data requirements, making data provision difficult.

Market information systems can also become the basis for electronic marketplaces. Electronic marketplaces do exist in the PRC but are localized and are often established for only a single specialized group of agricultural products. Other barriers exist, such as technological and organizational issues, which prevent farmers from using the system (Xiaoping et al. 2009). For these reasons, farmers currently have limited options for marketing their products.

Cold Chain Technology

Despite recent improvements in the use of refrigeration technologies for preserving fresh produce in the PRC, traditional storage and transportation methods are still the norm throughout the PRC's traditional food system. Throughout the process of agricultural logistics in the PRC's traditional food system, food products tend to be stored in the open air. Sometimes, farmers or brokers who are transporting perishable products may rely on traditional cooling methods such as ice and blankets for insulation, but they generally do not have refrigerated trucks or cold storage to keep their produce fresh. Traditional cooling methods tend to exacerbate spoilage rates, particularly if they are used to haul food over long distances.

Cold chain logistics are still in their infancy in the PRC. As of 2011, only 6.6% of fruits and vegetables, 17.2% of meat products, and 25.2% of fish and shellfish were distributed using cold chain logistics technologies (China Federation of Logistics and Purchasing 2012). The PRC's refrigerated warehouse capacity is only 7 kilograms (kg) per capita, and the number of

refrigerated vehicles account for only 0.3% of the total stock of vehicles, lagging far behind more developed economies. Existing refrigeration facilities are generally obsolete, with nearly half of state-owned refrigerated warehouses already in use for more than 30 years (NDRC 2010).

Moreover, the existing network of cold chain facilities lacks rationalization. Existing facilities are concentrated mainly in the eastern regions and major surrounding urban centers, creating a shortage of facilities in the central and western regions and areas where agricultural production is concentrated. Utilization rates for cold chain transport vehicles and infrastructure are also very low. Most warehouses with refrigeration capacity are only for meat and fish products, and their utilization rates are only 20%–30%. Several factors, including low demand for fresh, high-quality produce or the high costs of technology adoption, could cause low utilization rates for cold chain technology. Refrigerated trucks not only require a high one-time expenditure but also consume more energy than ordinary trucks during transport. This combined high cost of purchase and maintenance makes many enterprises unwilling to use them for low-value farm produce, leading to low utilization of cold chain systems. The same is true for the refrigerated warehouses (Ding 2010).

Summary

The research on agricultural logistics identified five key sources of inefficiency in the PRC's traditional food system: scale of operation, packaging standards, product grading and food safety, market information systems, and cold chain capacity. In the next chapter, we summarize the results of a business process analysis to provide more detailed evidence on these sources of inefficiency.

CHAPTER 3

Business Process Analysis

To provide empirical evidence about the logistical challenges experienced throughout the traditional food system of the People's Republic of China (PRC), we conducted a field-based business process analysis (BPA) of two products: lettuce and pork. Consumers in the PRC consider these goods important food products, and the products represent the problems and challenges of the PRC's traditional food system. Our BPA involved structured interviews with market participants at different stages of the agricultural logistics process, collecting quantitative and qualitative data along several dimensions.

To supplement the quantitative information collected in the field-based BPA, we also conducted structured, qualitative surveys of experts in the private and public sectors in the field of agricultural logistics. This qualitative survey included questions about the extent of cold chain technology penetration throughout the system, different factors that influenced the adoption of cold chain technologies, and major barriers to and weaknesses of the current system.

In this chapter, we first describe the methodology behind the field-based BPA and the expert surveys. We then describe the results.

Methodology

Field-Based Business Process Analysis: Lettuce

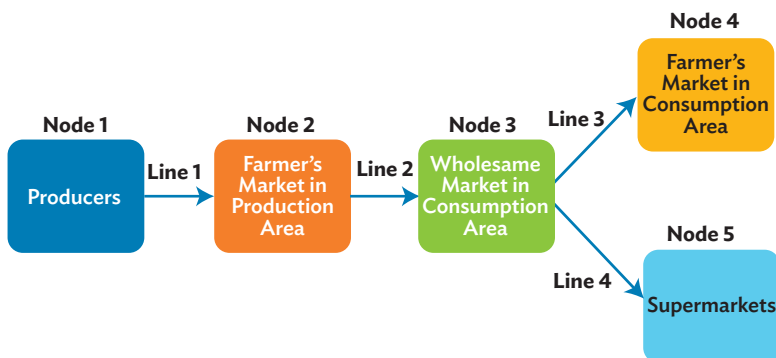
To focus the BPA surveys effectively, we chose to study logistics in and around a single production center: Cangshan County in Linyi City, in Shandong Province. According to official statistics, Shandong is one of the largest agricultural production centers in the PRC. Linyi is near where many vegetables and meat products are produced. Produce from Linyi is typically distributed to major consumption areas such as Shanghai or other cities in the Yangtze River delta. Because lettuce and pork produced in Shandong Province are consumed as far away as Shanghai, a distance of nearly

600 kilometers (km), studying these supply chains allows us to understand the challenges associated with long-distance agricultural logistics.

As a first step in conducting the field-based BPA, we constructed a map of the supply chain, end to end, from a single production area to major consumption areas. The supply chain map consists of two key elements: nodes and lines. Nodes represent the key production or collection points in the supply chain, including farms, wholesale markets, and retail markets. Connecting the nodes are lines that represent various methods of moving goods from one node to another. As an example, Figure 3.1 shows the value chain map used for the lettuce BPA. This supply chain begins on farms in Cangshan County, Shandong Province and ends at the final retail market in Shanghai. It consists of five nodes: production, the farmers' wholesale market in the production area, the wholesale market in the consumption area, the farmers' retail market in the consumption area, and supermarkets in the consumption area. Four lines that represent transportation between adjacent nodes connect these nodes together.

We used the supply chain map to organize our approach for data collection. After identifying the structure of the supply chain, we designed questionnaires to collect several different pieces of information, including profiles of market participants, prices of goods at different stages, costs of transportation and storage, time spent in transit and in storage, quality changes, losses and waste, status of logistics facilities, and methods of

Figure 3.1: Supply Chain Map for Lettuce Business Process Analysis from Cangshan to Shanghai



Source: Development Research Center of the State Council.

shipping and handling. We sent these questionnaires in paper format to selected individuals and organizations associated with each of the key nodes and lines in the supply chain. The specific individuals and organizations we contacted for interviews were recommended by the Commerce Committee of Shandong Province.

We designed separate questionnaires for each of the nodes and lines. Table 3.1 provides information about the questionnaires for each of the different nodes and lines and about the number and types of respondents. The survey questionnaires were sent to the identified respondents. Contact information was also provided in case respondents have questions about items in the questionnaire. Accomplished survey questionnaires were reviewed for consistency, and a sanity check was also performed. We collected data on three or four respondents at each site, although sometimes we interviewed the same person about different sites. We followed up with respondents to address any missing information or answers that needed clarification.

Table 3.1: Questionnaire Respondents and Contents of the Lettuce Field-Based Business Process Analysis

Location	Description	Respondents
Node 1	General situation of production and distribution in the producing area	Lin Qingjiang, deputy director of the Bureau of Commerce of Cangshan County Fu Chenggao, head of the Quality Safety Supervision Office for Farm Produce of Cangshan County Hu Yucai, general manager of Huakai Co-Op of Cangshan County Households in the storage, transportation, and sales businesses for garlic sprouts in Cangshan County

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Table 3.1 *continued*

Location	Description	Respondents
		Chen Mingjun, head of the Garlic Branch of the China Vegetable Marketing Association
Line 1	Logistics from farms to producers' wholesale markets	Hu Yucai Wholesalers at Huakai market Households in the storage, transportation, and sales businesses for garlic sprouts
Node 2	Sales and logistics at the producers' wholesale markets	Hu Yucai Wholesalers at Huakai market Households in the storage, transportation, and sales businesses for garlic sprouts
Line 2	Logistics from producers' wholesale markets to consumers' wholesale markets	Hu Yucai Wholesalers at Huakai market Households in the storage, transportation, and sales businesses for garlic sprouts
Node 3	Sales and logistics at the consumers' wholesale markets	Hu Yucai Wholesalers at Huakai wholesale vegetable market
Line 3	Logistics from consumers' wholesale markets to retail farmers' markets	Hu Yucai Wholesalers at Huakai market
Line 4	Logistics from consumers' wholesale markets to retail supermarkets	Hu Yucai Wholesalers at Huakai market

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Table 3.1 continued

Location	Description	Respondents
Node 4	Sales and logistics at the farm-produce markets in selling areas	Vegetable wholesalers from Cangshan County operating in the major selling area
Node 5	Sales and logistics in the supermarkets in selling areas	Vegetable wholesalers from Cangshan County operating in the major selling areas

Note: For descriptions of the nodes and lines, see Figure 3.2.
Source: Development Research Center of the State Council.

Field-Based Business Process Analysis: Pork

We conducted our BPA for pork logistics similarly to the BPA for lettuce, using detailed node- and line-specific surveys to cover a single supply chain. Again, we chose Shandong Province as the location for the surveys because it is one of the PRC’s major pork-producing provinces, with 42.3 million hogs, or 6.4% of the PRC’s total, prepared for slaughter in 2011. The cities of Linyi and Weifang account for much of Shandong’s pork production, and they are home to Linyi Xincheng Jinluo Meat Products Group and Shandong Delisi Food Company, two of the largest hog slaughtering enterprises in the PRC. These two cities were the focus of the survey.

As shown in Table 3.2, a total of 27 respondents were interviewed and completed the questionnaire. We took these respondents from almost every node and route involved in the logistics process for pork and included hog-raising farmers and co-ops, hog brokers, slaughtering enterprises, meat wholesalers and retailers, carriers, and logistics providers. We also included the local government and authorities involved in the pork industry in the survey.

Table 3.2: Questionnaires and Respondents of the Pork Field-Based Business Process Analysis

Survey	Description	Respondents
1	Situation of pork-producing area	Yishui County government Commerce Bureau of Yishui County Agriculture Bureau of Yishui County
2	Hog raising and selling	Five farmer households major in hog raising One hog corporation
3	Hog purchasing and logistics	Three hog brokers
4	Slaughtering and pork flow direction	Five slaughtering firms
5	Wholesale market	Two wholesale markets
6	Pork logistics delivery	Three pork logistics firms
7	Selling and logistics of pork in supermarkets	Three supermarkets
8	Selling and logistics of pork in farm-produce markets in city communities	Two farm-produce markets

Source: Development Research Center of the State Council.

Expert Interviews

We conducted a series of qualitative interviews with several key experts, market participants, and policy makers about the extent of cold chain technology penetration, the potential for further development, and the strengths and weaknesses of the PRC's traditional food system. The survey focused on several different aspects of agricultural logistics and food markets, including consumer demand; industrial organization; technology; human resources; compatibility between upstream and downstream industries; market competition; existing standards, laws, and regulations; and the policy system.

Only experts who have a full understanding of the current situation and familiarity with existing policies were included in the interviews, and each was chosen to be representative of a particular sector or industry. As shown

in Table 3.3, we administered the survey to 15 experts from the following types of organizations: seven from universities and research institutes, four from industry associations, one from a distribution enterprise, and three from government agencies. Only one respondent selected for an interview did not participate. Although we interviewed only a small number of experts whom we did not randomly select, their backgrounds and understanding of the situation provided insight on the challenges that agricultural logistics in the PRC face.

Table 3.3: Information about Interviewed Experts

Type of Respondent	Organization	Surveyed	Responded
Universities and research institutes	China Agricultural University, Beijing Wuzi University, and the DRC	7	6
Industry associations	China Vegetable Marketing Association, Cold-Chain Branch of the China Federation of Logistics and Purchasing, China National Agricultural Wholesale Markets Association, and China Fruit Marketing Association	4	4
Enterprises in distribution	Xinfadi Agricultural Products Company	1	1
Government agencies	MOA Department of Market and Economic Information, MOFCOM Department of Market System Development, and Department of Commerce of Shandong Province	3	3

DRC = Development Research Center of the State Council, MOA = Ministry of Agriculture of the People's Republic of China, MOFCOM = Ministry of Commerce of the People's Republic of China.

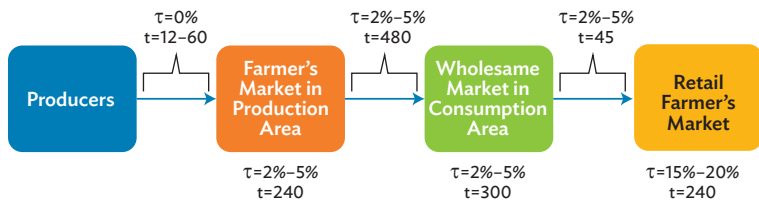
Source: Development Research Center of the State Council.

Findings from the Business Process Analysis for Lettuce

The main findings from the BPA for lettuce are the following:

- The farmers' cooperatives were very small in size and in terms of operations. For example, one county in Linyi City had more than 1,500 distinct farmers' cooperatives for vegetables alone.¹²
- Lettuce is generally handled at ambient temperature and is neither precooled at harvest sites nor refrigerated throughout the entire distribution process.¹³ As a result, the entire logistics process must be completed within 24 hours to guarantee freshness and quality, although some spoilage can occur even within the 24-hour time frame. According to our BPA, vegetables take around 20 hours to move from production areas to retail markets. Figure 3.2 shows the spoilage rates and travel times for lettuce as it makes its way to

Figure 3.2: Spoilage Rates (τ) and Transport Times (t) for Cangshan Lettuce



Notes: This figure shows the spoilage rate, denoted by τ , and the time in transit (or in storage), denoted by t and expressed in minutes, between different nodes and lines of the agricultural logistics process. These spoilage rates are not cumulative. For example, in the farmers' market in a production area, goods waited an average of 240 minutes, and 2%-5% of the goods spoiled while at the market.

Source: Business process analysis.

¹² The county under study was Cangshan County, which had a harvest area of 68,000 ha for vegetables and a total output of 3.82 million tons, valued at CNY7.16 billion, in 2012.

¹³ For one particular farmers' cooperative surveyed, only 10% of the volume was precooled and refrigerated during transport.

wholesale markets in production areas, then to wholesale markets in consumption areas and retail markets in consumption areas. The largest portion of losses and waste takes place at retail markets. This most likely reflects the fact that, for most vegetables, spoilage tends to happen later in product life, during ripening and senescence, when fruits and vegetables are most vulnerable to natural decay and fungal contamination (Barth et al. 2009). However, significant losses and waste also occur throughout the distribution chain because of water evaporation and damage from handling. Proper packaging and cooling operations, used throughout the entire distribution process, would reduce spoilage rates considerably.

- Using the spoilage rates and price differences between locations in the supply chain, we estimated the magnitude of logistics costs. Given the large number of intermediaries in the system and their low barriers to entry, it is reasonable to assume that intermediaries are acting in a competitive market, so the differences between prices at different locations reflect both the costs of moving goods between those locations and spoilage rates. Using a simple approach, described in more detail in Appendix 2, we calculated ranges of the logistics costs along each stage of the supply chain and expressed them as fractions of the price differences between locations (Table 3.4). Moving lettuce between producer and consumer wholesale markets leads to a significant 50%–60% increase in prices, and more than 70% of that price increase is due to logistics costs. Moving lettuce from consumer wholesale markets to retail markets leads to only a 22%–25% increase in prices. Between 45% and 80% of that price increase is due to logistics costs.
- Note that for lettuce, price differences between farms and retail markets in the PRC were smaller than those in the US. In the US, retail prices for iceberg lettuce were 3.7 times higher than farm prices in 2013; in the PRC, retail prices were between 2.2 and 3.3 times higher than farm prices (Economic Research Service 2016). However, differences in market structure in the US also play a significant role. Concentration of market players in several areas, including food processing, packaging, and retail markets, allow for significant markups to be charged along the way (Sexton and Lavoie 2001).
- For lettuce, total spoilage rates are only about 7% in the US; we estimate the cumulative spoilage rates from farms to retail markets to be between 21% and 35% for the PRC (Economic Research

Table 3.4: Price Differences, Spoilage Rates, and Logistics Costs of Cangshan Lettuce

Point in the Process	Price per 0.5 kg		Spoilage Rate (%)		Logistics Costs (Share of Price Differences)	
	Low	High	Low	High	Low	High
Farm	0.6	1.0				
Transport: Farm to producer wholesale market			0.0	0.0		
Producer wholesale market	1.0	1.2	2.0	5.0	0.0	0.3
Transport: Farm to consumer wholesale market			2.0	5.0		
Consumer Wholesale market	1.6	1.8	2.0	5.0	0.7	0.9
Transport: Consumer wholesale market to retail market			2.0	5.0		
Retail market	2.0	2.2			0.5	0.8

kg = kilogram.

Note: See Appendix 2 for details about how we calculated the logistics costs as a share of price differences.

Source: Business process analysis.

Service 2016).¹⁴ Although directly comparing logistics costs between economies is difficult because of differences in market structure, both logistics costs and spoilage rates for lettuce are substantially higher in the PRC, creating significant differences between prices across locations. Reducing logistics costs and spoilage rates to levels attained in the US, for example, could lead to significant gains in producer and consumer welfare. However, the precise welfare effects depend on the market structure that emerges as these logistics costs decline.¹⁵

- Our BPA for lettuce has several limitations. We only have a single cross-section of data; because of this, it is difficult to claim with certainty that price differences reflect transport costs, logistics costs, spoilage rates, or other factors such as markups. Our analysis relies heavily on a model and the assumption of perfect competition at every stage of production and distribution. Although we feel that this is a useful approximation of the situation in the PRC, better research and more widespread data collection are needed to validate these assumptions. However, other studies using different methodologies have confirmed the large role that transport costs and intermediaries play in the PRC's supply chains. Reardon et al. (2012) estimated that for rice, total transport costs accounted for 28% of total value chain costs and increased retail prices by 12%. For potatoes, total transport costs were 31% of total value chain costs and led to a 24% increase in retail prices. Wage costs of traders throughout the potato value chain were 11% of total costs and led to an 8% increase in prices.
- Use of cold chain technologies for lettuce and other vegetable products is starting to increase, especially during warmer months and when products are shipped to more distant destinations. These technologies are used most frequently during the summer and autumn, when goods are transported for more than 1,000 miles, or when transportation

¹⁴ Calculating these cumulative spoilage rates involves aggregating the spoilage rates at each stage of the process, as shown in Figure 3.3.

¹⁵ For example, Jensen (2007) showed that providing mobile phones to fishers in Kerala, India, drastically reduced the cost of information dissemination and resulted in integrated regional markets, reduced differences in prices between markets, and eliminated waste and spoilage. The welfare effect for fishers was positive even though fish prices were reduced because almost all unsold fish or waste was eliminated and sales income for fishers increased. These welfare effects required the market structure for producers to remain competitive. Sexton and Lavoie (2001) argued that improved logistics costs changed market structures in many agricultural markets in the US, leading to different welfare effects.

lead times are more than 10 hours. Although refrigerated vehicles are available, vegetable carriers use rudimentary technologies, such as ice bottles and blankets, to insulate the lettuce and preserve its freshness. Although these technologies might be adequate for short distances, they are unsuitable for long-distance shipment.

- As demand for cold chain vegetable logistics increases, storage capacity becomes difficult to find, especially in production areas. This is true for vegetables that have concentrated harvest times and are sold throughout the year after a long period of cold storage. The demand for these products comes primarily from consumers with middle- and higher-income levels in large cities who desire fresh, high-quality produce.

Findings from the Business Process Analysis for Pork

The BPA for pork revealed two distinct systems of distribution for pork products in the PRC: the low-end market that consists of small and medium-sized hog-farming households, small and medium-sized slaughtering enterprises, wholesale markets, and farm-produce markets in cities; and the high-end market, in which hog production, slaughtering, and pork distribution are vertically integrated. Given the scope of this report, we focus on the traditional, low-end market. Our findings are as follows:

- In the traditional, low-end pork production and distribution system, small-scale slaughtering firms are the key market participants. These small enterprises are typically not well equipped. Their main product is traditional carcass meat kept at room temperature. Meat quality is low and can vary widely. Hogs in the low-end system are usually slaughtered with low-quality equipment under poor sanitary, hygiene, and safety conditions. In these enterprises, staff tend to be poorly educated and not well trained in proper slaughtering techniques. This is in contrast to slaughtering in the higher-end system, in which large, well-equipped enterprises slaughter hogs using advanced technologies, sanitary practices, and cold chain storage and processing, leading to consistent quality.
- In the traditional system, pork is distributed mainly through wholesale markets or directly to farm-produce markets in the city. Throughout the logistics processes, which consist of slaughtering, wholesaling, and

retailing, pork is kept at room temperature, increasing the possibility of contamination. In the middle and high-end systems, chilled cuts of meat and carcasses are distributed directly to supermarkets and specialty retail stores, which have cleaner and more sanitary environments.

- The lower-end system tends to satisfy the demand of low-income households, small-scale restaurants, and canteens. The comparatively low price and convenience of the farm-produce markets in cities attract these consumers to this type of pork. However, supermarkets and other modern retailers are offering higher-quality shopping environments and logistics standards. As their costs have begun to fall, they have begun to rapidly expand their market share and have become the main consumer outlets for high- and middle-income households.

Findings from the Expert Interviews

The main findings from the expert interviews are as follows:

- Cold chain technology is used at a much higher rate in the modern, farm-to-supermarket distribution system than in the traditional food system, which is oriented toward wholesale markets. Big gaps in technology, equipment, and facilities exist between these two systems.
- Because of a growing demand for higher-quality produce and meat products, consumer demand for greater use of cold chain technology in the traditional food system is strong, and existing technologies are adequate for meeting these demands. However, inadequate human resources, existing laws and regulations, the policy system, and the small size and scale of producers are all holding back greater penetration of cold chain technologies. Notably, the lack of modern industrial organizations in the traditional food system; the small size of market players; and the fiercely competitive, fragmented production and distribution market are all working against greater penetration of cold chain logistics.
- The two weakest links in the traditional food system, both of which suffer from low adoption of cold chain technologies, are the points of origin (producers) and the traditional retail markets. When we asked experts to evaluate nodes and lines, the majority indicated that cold chain logistics at traditional retail markets (farmers' markets) and

places of origin are very poor. Greater cold chain storage capacity at traditional farmers' markets is badly needed and could encourage greater adoption at earlier nodes and lines.

- Cold chain logistics for meat products tend to be much more developed than cold chain logistics for vegetables. The biggest gaps in cold chain development between meat and vegetables occur in places of origin and wholesale markets (particularly those located close to production areas).

CHAPTER 4

International Experience Study

Investigating the experiences and lessons from others that have modernized their agricultural logistics systems is an important step in formulating policy recommendations for the People's Republic of China (PRC). By understanding the history and development of agricultural logistics in comparator economies—including different policies, inputs, outputs, and outcomes across various settings—we identified various policy options for the PRC and evaluated the context in which those policy options might apply to the current PRC environment. The PRC has a unique set of institutional and historical circumstances that affects the policies and development of agricultural logistics. But practical experiences from others, appropriately tailored to the PRC's market and business environment, can provide guidelines for policy making.

Methodology

To conduct a comparative policy analysis on agricultural logistics development, we first conducted a literature review. This review focused initially on assessing the current landscape of agricultural logistics of various economies. Then we investigated the major policies that their governments used to modernize agricultural logistics, attempting to understand the context and experiences surrounding major policy initiatives, and the extent to which such initiatives were successful. Where the literature was inadequate, we also relied on interviews with relevant agricultural logistics experts in the areas of government service, industry associations, and enterprises.¹⁶

We considered two critical factors in selecting comparators for the policy analysis: the comparator must have achieved an advanced state of agricultural logistics, with a vertically coordinated flow of products through the system;

¹⁶ Both government and the private sector influence the logistics system development. This study, however, focused on public policy's role in shaping the logistics system, rather than on coverage of private sector-led development.

and the comparator and the PRC must have similarities in one or more areas that affect the development of agricultural logistics. One of the important indicators we used to measure the state of advancement of agricultural logistics system is the spoilage rate, i.e., the percentage of fresh produce that is lost from the time of harvest to reaching consumers that is caused by lack of proper control of environmental factors, including temperature and humidity. The extent to which refrigeration is used during storage and transport strongly affects the spoilage rate. The economies that have low spoilage rates tend to be wealthier than others, measured by higher per capita gross domestic product (GDP), and they tend to have higher urbanization rates, measured as the proportion of the population living in urban areas. At one point in time, all economies with modern agricultural logistics had high spoilage rates comparable to that of the PRC's because of the absence or low penetration of advanced cold chain technologies. Reductions in spoilage started with primitive methods, such as harvesting ice from ponds, to cool products during storage and transport.

Another important factor taken into consideration when selecting comparators was their similarity to the PRC in their production and distribution systems. It is unlikely that the PRC's fragmented production structure, with many small-scale farmers, will change in the near term, so it was important to find examples that have achieved modern logistics and vertical coordination and still have a large presence of small farmers. Similarly, the presence of wholesale markets is an important factor because the PRC relies heavily on these intermediate points in the distribution system to coordinate the shipment of goods between producers and consumers.

Using these selection criteria, we identified three economies or entities for comparison: Japan; Taipei,China; and the United States (US). The US is comparable to the PRC in terms of total land area. All three are currently much wealthier than the PRC. Today, per capita GDP in the PRC is now only 10% of that in the US; less than 15% of that in Japan; and less than 30% of that in Taipei,China, but these differences will grow smaller over time as the PRC's economy expands. Japan; Taipei,China; and the US currently have higher urbanization rates than the PRC. Approximately 82% of the population in the US currently lives in urban areas, and this figure is similar for Taipei,China. Japan is also exceptionally densely populated, with an urbanization rate of 91%. All three economies are much more urbanized than the PRC, which currently has 50% of its population living in urban areas. However, the PRC is rapidly urbanizing, and we expect this trend to continue due to recent policies that the PRC has enacted.

We selected them for having successfully made advances in the agricultural logistics systems, as shown by their low spoilage rates (Table 4.1). Furthermore, they have similarities in the structure of the value chain that make a comparative policy analysis relevant to the PRC. Japan and Taipei,China have very strong presences of small-scale farming and rely heavily on farmers' organizations for coordinating production and distribution. Although the US production system tends to be associated with much larger-scale production, US government policy experiences might be of interest to the PRC in evaluating opportunities for large-scale farming. Japan and Taipei,China are also very similar to the PRC in terms of the important role of wholesale markets, which handle the vast majority of products flowing from the producers to consumers. All three economies have employed cold chain technologies throughout the value chain to achieve efficiencies in the logistics system.

Table 4.1: International Experience Study—Key Economic Indicators and Agricultural Logistics Characteristics

Indicator	Japan	Taipei,China	United States	PRC
Spoilage rate, as a percentage	<5	<5	1–2	~30
Land area, in millions of hectares	36.6	3.6	914.7	938.8
Arable land, as a percentage of total area	11	24	16	12
Average farm size per farm household, in hectares	~2	~1	187	2.5
Percentage of agricultural products passing through whole-sale markets	80	87	80	70
Per capita gross domestic product	46,707	20,336	51,704	6,072

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Table 4.1 *continued*

Indicator	Japan	Taipei,China	United States	PRC
Urbanization rate, as a percentage of the population	91	>80	82	~50
Annual urban growth rate, as a percentage	0.6	0.8	1.2	2.9

PRC = People's Republic of China.

Note: Per capita gross domestic products are 2013 figures measured in current US dollars, provided by the International Monetary Fund.

Sources: For Japan: NDRC 2011; Ministry of Agriculture, Forestry and Fisheries of Japan 2012b; CIA 2013. For Taipei,China: Zhao 2006; International Monetary Fund 2015; Lo and Yeung 1996. For the United States: NDRC 2011; Food and Agriculture Organization of the United Nations 2013; CIA 2013. For the PRC: *Supply Chain* 2010; World Bank, undated; National Bureau of Statistics 2013; National Bureau of Statistics of China 2012.

Overview

Production

Agricultural production in Japan; Taipei,China; and the US takes place on the relatively small fraction of land suitable for agriculture. Taipei,China has a total area of roughly 3.6 million ha, less than 0.5% of the PRC's total area. The island is long and narrow, and only 37% of the island's physical area is arable, requiring a sophisticated agricultural logistics system to meet the demands of its population, which is more than 23 million (Chou and Chang 2008). In Japan, only 4.25 million ha of land is arable (11% of the total land mass). The US has a much larger land area, comparable to the PRC's, but only 16% (160 million ha) of the area is arable.

Similar to that in the PRC, agricultural production in Japan and Taipei,China is dominated by small farmers, making these economies favorable for comparative study with the PRC. Despite some regional differences, the average farm size in Japan is between 1 ha and 2 ha. The island of Hokkaido is an exception. Farms in Hokkaido are much larger and have been increasing at much faster rates than in other regions. Although the number of farmers in Hokkaido accounts for less than 3% of the total farmers in Japan, the agricultural output amounts to more than 12% of total output, indicating

higher efficiency of farming in Hokkaido. Farming in the northern island of Hokkaido is on a larger scale than in the rest of Japan and reflects the influence of government planning in the late 19th century, which included assistance from US farm specialists.

In Taipei,China, there are about 775,000 farm households, with an average size of just more than 1 ha. The fact that Japan and Taipei,China have small average farm sizes makes them quite comparable to the PRC, with an average farm size of only 2.5 ha per household. Implementing cold chain agricultural logistics is very challenging and costly in environments with small-scale, decentralized production. The fact that Japan and Taipei,China have overcome those challenges means that their experiences should provide informative lessons for the PRC.

On the other hand, in the US, there were 2.2 million farm households in 2011; on average, each farm was working 187 ha (FAO 2013).¹⁷ In the US, modern agricultural logistics came about largely through farm consolidation. This is another path that the PRC can take. Despite the consolidation of smaller into larger farm units, the US still has a strong presence of small farmers in terms of number.¹⁸ However, the small farmers account for just 1% of the total value of production.

Distribution

In both Taipei,China and Japan, farmers' organizations (or agricultural cooperatives) play an important role in the distribution of agricultural products; wholesale markets are dominant in linking production to consumption, like in the distribution landscape in the PRC. In Japan, agricultural cooperatives are largely responsible for collecting produce from farmers and organizing distribution to wholesale markets. According to a national agricultural distribution channel survey conducted by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, close to 80% of domestically produced vegetables and fruits are distributed through wholesale markets.

In Taipei,China, 53% of agricultural products are distributed through cooperative organizations, while 47% are distributed through brokers.

¹⁷ Calculated by dividing total agricultural area by the number of farms (commercial and noncommercial) in the US.

¹⁸ In the US, 54% of all farms are very small (or noncommercial), having incomes of less than \$10,000 (Hoppe 2010).

As they make their way to consumers, 87% of products pass through wholesale markets. The important roles of both agricultural cooperatives and wholesale markets in both Taipei,China and Japan are similar to the way in which the agricultural supply chain is organized in the PRC.

Distribution in the US tends to be different. In general, there are a variety of different types of supplier–wholesaler–retailer relationships, so it is difficult to generalize. These often vary by type of product and product quality. However, the importance of direct, contract growing trade, through which farmers work directly for food processors or retailers, has grown over time. Horizontal integration of the production process is one way in which agricultural logistics can be modernized, but, as the examples of Japan and Taipei,China both illustrate, it is by no means the only path.

Nevertheless, wholesale markets remain central to the agricultural logistics system in the US. Close to half of all fresh produce distributed in the US moves through the wholesale markets (Cook 2012). This system connects producers on one end of the system with retail outlets and food service establishments on the other end. However, what makes the wholesaling industry in the US different from those in Japan and Taipei,China is that, in many cases, enterprises purchase goods from suppliers and hold them in wholesale markets until they are sold to the next party in the supply chain. Such inventory-carrying wholesalers are different from the wholesale markets dominant in Japan and Taipei,China, in which goods are sold and bought through spot trading.

Scale of Operation and Farmers' Organization

Agricultural logistics and vertical coordination are exceptionally challenging when farm production takes place in a highly decentralized, small-scale manner, like it does in the PRC. However, the experiences of Japan and Taipei,China have shown that modern logistics can be achieved in a small-scale production environment. One way in which Japan and Taipei,China have accomplished this is by having the government play a role in promoting and enhancing the development of farmers' organizations. By bringing together small farmers and allowing them to operate as a single entity, farmers' organizations increase the scale in purchasing, production, marketing, and distribution, thereby reducing transaction costs and increasing overall efficiency. They also increase producer market power and help farmers obtain more favorable input and output prices.

Both Japan and Taipei,China have large, cooperative systems with hierarchically structured organizations across geographic regions. These associations of farmers handle a large volume of agricultural produce in distribution. Today, most farm households in Japan are current members of the Central Union of Agricultural Co-operatives (JA). The organization's branches exist at the local, prefectural, and national levels. As of April 2013, there were 708 JA branches throughout Japan (Norinchukin Bank 2013). JA supplies its members with a comprehensive range of services, including input supplies, farm management advice, marketing assistance, and insurance and other financial services. JA also plays a key role in agricultural logistics. JA farmers sell their produce to the cooperative, which collects, sorts, and distributes products to upstream wholesale markets. The cooperative handles 95% of all marketed rice and distributes about 80% of all agricultural subsidies in Japan to the villages. JA has had a long-standing political affiliation with the Liberal Democratic Party of Japan, which was in power until 2009. JA's strong rural membership base has been used to get political patronage in return for favorable agricultural policies and preferential treatment for the JA endeavors.

In Taipei,China, nearly every farmer is a member of a farmers' association—a centrally managed organization with multiple functions that include supply, marketing, promoting technologies, and providing credit and insurance. Today, farmers' associations in Taipei,China operate on three different geographic levels: provincial, county, and township. Within the same administrative level, farmers' associations are independent, but the higher-level organizations guide the decisions and policies of branches at the lower level. The farmers' association in Taipei,China has also developed more varied functions than that in Japan. The major duties of farmers' associations are supply and marketing operations, which link small farmers to large markets and enhance smaller farmers' market power. However, farmers' organizations in Taipei,China also construct infrastructure, procure production equipment, and support the development of various types of processing and storage facilities such as rice mills and warehouses. Every township has distinct production and marketing units that not only focus on disseminating new technologies but also grade, package, and distribute products. Some farmers' associations also participate in direct marketing, establishing fruit and vegetable distribution centers, supermarkets, and stores. Large associations also participate in the operation of wholesale markets. This is in contrast to the PRC, where farmers' cooperatives are highly fragmented. Centralization in farmers' organizations can help the government quickly set up and execute industry-wide reforms.

Governments can significantly influence farmers' organizations, even from their formation. In Japan, the government established cooperatives and mandated farmer participation in the beginning, thereby expanding the membership base and achieving economies of scale in farm operation. JA was established under the Agricultural Cooperative Society Law in 1947. Shortages of food and unemployment of agricultural engineers after World War II prompted reform and consolidation of the wartime-era cooperatives. Following the 1947 law, JA absorbed all the resources, activities, and employees of the preexisting cooperatives: Sangyo Kumiai and Nokai and became an umbrella organization for farmers' cooperatives (Bullock 1997). In Taipei, China, the government also played an active role in encouraging farmers to join cooperatives by offering various forms of incentives.

The experiences from Japan and Taipei, China reveal different choices in the level of government intervention in the management and operation of farmers' organizations after they are established. In the late 1950s, when Japan experienced a reduction in agricultural productivity, the government created a structural improvement plan to reform JA, shifting the organization's focus from providing guidance to individual farmers to providing guidance to groups of farmers in a region. This effort also entailed an expansion of agricultural land for mass production and promotion of crop-specific organizations. Under this "agricultural parks" concept, farmers worked collectively and created a consistent and standardized system of production, distribution, and shipping. It simplified the distribution process and eventually improved management of the cooperative. This effort also resulted in less waste, less spoilage, and a reduced role for intermediaries, which ultimately led to increases in farmers' incomes. Also, to address the low-productivity issue, the agricultural cooperative decided to strengthen the supply-side management by focusing on several major products. Product-centered planning entailed more effective use of land and led to even greater consolidation of regional farming groups, promoting efficient use of resources for production.

In Taipei, China, the government is still deeply involved in the operation of farmers' associations. The Council of Agriculture of Executive Yuan is the central authority in charge of farmers' associations, while county and city governments are the local authorities. Central and local authorities guide and supervise all of the businesses and goals of farmers' associations. Regulation and guidance from Taipei, China's government include developing farmers' associations' personnel and financial management rules, selecting organization managers, setting evaluation and dismissal rules, supervising staff qualification examinations, and approving the

establishment of farmers' associations' offices. In the century-long history of farmers' associations, government intervention has played a critical role in the health and development of farmers' associations.

Findings also indicate that strong government interventions in management can put individual farmers' interests at risk, such as in Japan, where too much power was concentrated on the ruling bodies of the cooperatives and the cooperatives were accused of focusing more on maintaining themselves than on helping farmers. The authorities in Taipei, China addressed such problems by instituting participatory decision-making systems (e.g., making important decisions democratically through voting) to ensure that the power is distributed to the farmers themselves.

Consolidation of Farms in the United States

The US is known for large-scale farming, as indicated by the average farm size of 187 ha, which is significantly larger than those of the PRC; Japan; and Taipei, China. This large-scale farming was achieved with a significant reduction of farmers, both in their absolute number and in proportion to the population. In 1935, the number of farms in the US peaked at 6.8 million as the population edged over 127 million citizens. Today, the number of farms in the US stands at about 2.2 million. Among more than 313 million people living in the US, less than 1% claim farming as an occupation. In 2007, only 45% of those who identified themselves as farmers claimed farming as their principal occupations (United States Environmental Protection Agency 2013).

Small farms in the US continue to exist, often because they specialize in the production of high-quality, organic fruits and vegetables and can charge a premium for their products. However, in general, large-scale farms are the most important producers of agricultural products in the US. As the number of farmers has declined, and as fewer people live and work in rural areas with increasing urbanization, the consolidation of farms has simplified agricultural logistics and made it possible to reap major economies of scale in transportation and logistics. With increasing vertical integration between producers, processors, and retailers, many large agribusiness firms internally manage the logistics of getting food from farmers to retailers themselves, without any government assistance. The use of capital-intensive farm equipment, improved crop varieties, commercial fertilizers, and pesticides has aided increases in the scale of production. The US model of consolidating farms into larger plot sizes, reducing labor intensity by encouraging the growth of mechanized farm production, and encouraging vertical relationships will

naturally lead to more modern agricultural logistics because it simplifies the distribution system significantly.

However, this approach has not benefited everyone equally. For instance, Sexton and Lavoie (2001) argued that in the US, vertical integration and consolidation in pork and poultry have led to efficiency improvements that reduced consumer prices, but they have come at the expense of producer welfare. Consolidation in slaughtering operations enabled those organizations to cut costs and improve efficiency, but it also increased their market power for live hogs and chickens, leading to lower producer prices—which hurts farmers, but also lowers consumer prices. Large-scale farming and industrial agricultural can also have adverse effects on the environment, especially in the case of concentrated livestock operations (Horrigan, Lawrence, and Walker 2002). The US model is one approach that the PRC could adopt to modernize logistics, but the examples of Taipei, China and Japan indicate that it is clearly not the only path.

Packaging Standards

In most markets, the adoption of packaging standards seems to emerge organically as a result of continuous, repeated interactions between market participants. Market forces might require individuals to coordinate on uniform standards even in the absence of government policies; for instance, in ancient Greece, standardized amphorae¹⁹ were used to transport wine and other goods as early as the 6th century BCE.

In Taipei, China and Japan, where agricultural cooperatives play an important role in organizing production and distribution, the cooperative plays a decisive role in selecting the packaging standard used for different products and enforcing its adoption. Horizontal integration of producers, which the cooperative structure achieved, ensures that all producers of the same goods make use of the same packaging standards. Products are accepted at cooperative-run markets, wholesale markets, and retail markets only if they are shipped in appropriate containers.

In Taipei, China, for example, many vegetables are packaged in standardized cartons that are provided by farmers' association, a network of farmers that facilitates product marketing and supply. The cartons are marked with

¹⁹ An amphora is an ancient Greek jar or vase with a large oval body, narrow cylindrical neck, and two handles used for holding liquids.

key information about the origin of the produce, product grade, and the specific producer, using a coding system to identify the product and the farmers. Standard pallet sizes are used to load and unload the cartons of vegetables at the location of pickup and arrival. Use of standard packaging facilitates handling and transaction at downstream points of the supply chain (e.g., at the wholesale markets, where products are easily identified and automatically captured by the information system). Investment in packaging standards has provided benefits along the supply chain by enabling faster processing and reducing product loss.

In Taipei, China, the farmers' association plays a critical role in implementing this system of product packaging standards. Farmers are required to use the association's packaging materials, including labels and point-of-origin tags, which enable the association to establish a quality traceability system. It is difficult for products without these labels to enter the market. In the case of fruit, farmers' associations have production and marketing units that are responsible for disseminating quality standards. These units hold several meetings each month to discuss problems that farmers face and experiences in encouraging high-quality standards. In addition, farmers' associations often conduct technology training, seminars, a variety of learning activities, demonstrations, field trips, technology competition, and other activities to help farmers master technologies and establish the awareness of quality standards and brand requirements. Moreover, farmers' associations emphasize education because they believe that it is the only way to ensure that farmers will follow quality standards consciously.

In addition, in wholesale markets, each production and marketing unit has a code, and each member of a unit has a subcode. Both the unit code and member code are printed on the package. Using the information system, farmers can check the prices of their products and others using an online database or by phone. Using the principle of lower price for low quality and higher price for high quality, farmers can easily see the difference of quality and profits between them and other farmers. This system provides strong incentives for farmers to effectively manage production and distribution (Fang et al. 2007).

Product Grading and Food Safety

Mislabeling, adulteration, and safety concerns are common problems in markets for food products. In the US, national legislation on food safety was enacted in response to news about unsanitary conditions in the meat

packing industry. Upton Sinclair wrote a novel, *The Jungle* (1906), which exposed unhealthy practices in meat packing plants in Chicago. The success of the novel, and the publicity it generated, provided impetus for national legislation on food safety, leading to the passage of the 1906 Pure Food and Drug Act (Pub. L. 59-384) and Federal Meat Inspection Act (Pub. L. 59-242). Because of investigative journalism and continued pressure from the media, and because of public health concerns, Congress passed several other pieces of legislation regarding food safety, including the Poultry Products Inspection Act (Pub. L. 85-172, 1957), the Humane Methods of Slaughter Act (Pub. L. 85-765, 1958), and the Egg Products Inspection Act (Pub. L. 91-597, 1970).

The United States Department of Agriculture (USDA) enforces these laws and created a food safety inspection system that the Food Safety and Inspection Service administers. This system of inspecting food evolved gradually. In 1884, inspection was first introduced at ports, where products were tested for foreign animal diseases. Inspection gradually expanded to domestic meat, poultry, and eggs. Inspection methods evolved from sight, touch, and smell to science-based methods. The US Food and Drug Administration also plays a major role in food safety. It oversees safety and labeling for food involved in interstate commerce, as well as other categories of items, including drugs, makeup, and medical devices.

Many industry associations were directly involved in the politics of determining and changing meat grades in the US. Associations, such as the Better Beef Association, the American Meat Institute, and the National Live Stock and Meat Board, played a significant role in the early development of meat grades. These organizations were strong proponents of federal beef grading and were instrumental in implementing the grading. The industry associations had used their own systems to differentiate the quality of beef, but the federal government harmonized and standardized these systems, codifying them in national regulations.

For most changes in beef grading, the National Cattlemen's Beef Association and its predecessor organizations worked hard to improve grading to better reflect consumer desires. The association has formed many task forces, committees, and subcommittees over the years to study beef grading and to make recommendations to USDA about possible changes in beef quality and yield grading.

In the 1950s, a series of federal court cases in the US were brought against food producers who used slack-fill procedures or mislabeled

their containers to deceive consumers and earn greater profits. Unclear rules and regulations in existing laws led to the creation of the Fair Packaging and Labeling Act (Pub. L. 89-755, 1966). This act requires food labels to state the following: the identity of the product, the manufacturer or distributor's name and place of business, and the quantity of the contents. The enforcement of this law, together with regulations that determine standards of identity for food, enabled differentiating products from one another more easily and tracking the sources of adulterated food.

Japan also had experienced a series of food safety scandals that led to an increased consumer awareness and demand for safer and higher-quality agricultural products. The Government of Japan enacted the Food Safety Basic Law in 2003 that established the Food Safety Commission. The principle of this law is similar to the European Union regulation of 2002 ("Regulation [EC] No 178/2002 of the European Parliament and of the Council of 28 January 2002," 2002). The Food Safety Basic Law introduced the method of risk analysis established in the European Union, the US, and the Codex Alimentarius Commission. The Food Safety Commission is empowered to independently perform risk assessment. The law is based on the main principles of providing protection and safeguarding consumers, creating and using safety measures in a scientific way, and ensuring that food is secure from "farm to table." It also requires that food safety measures be taken at all stages of production, including feed, pesticides, and veterinary drugs (Takahishi 2009).

Many food companies, facing the risk of being forced out of business if they mishandle the food safety requirements, have implemented traceability measures. Some companies, especially supermarket chains, even set their own quality standards in addition to public safety requirements. Consumers are also increasingly demanding locally produced products. These factors have led to agricultural enterprises becoming more involved with farming operations to ensure that they are receiving quality products from their suppliers.

Japan introduced hazard analysis and critical control-point evaluations in 1995.²⁰ To facilitate the rapid withdrawal and recall of food products in the event of a food safety incident, individual business operators need

²⁰ Hazard analysis and critical control point evaluation is a systematic approach to ensure product safety through the continual monitoring and recording of processes that are particularly important for hazard prevention, from the receipt of ingredients through manufacture and shipping.

to have a capability for traceability by preparing and keeping records of transactions on file. With respect to rice, a law for keeping transaction records and relaying place-of-origin information was passed and went into effect in October 2010 (Ministry of Agriculture, Forestry and Fisheries of Japan 2010).

Taipei,China has attached great importance to food safety and achieved advanced levels of food quality and standards. In the past 30 years, major food safety incidents were not uncommon there, but Taipei,China has responded to these incidents and continued to improve the food safety system. An example is the adoption of a pesticide inspection regulation in 1995 when 11 consumers, after eating watermelon, had symptoms caused by excessive pesticide use.

Currently, Taipei,China's fruit and vegetable wholesale markets have pesticide residue test centers that deal with the detection of harmful substances before products are admitted to the market. Products that fail initial screening tests receive more thorough chemical testing for more accurate detection. Any products exceeding pesticide residue safety limits are destroyed, and producers responsible for those products are notified that they need to improve their production practices.

Moreover, Taipei,China has strict inspections that take place at production locations. Since 1994, almost every county has established a consultation station for safe use of pesticides, which inspects pesticide residue, and analyzes farmers' habits of applying fertilizers.

Market Information Systems

Governments can have a positive influence on market information and management in wholesale markets. Both Japan and Taipei,China operate market information systems with the aim of promoting efficient marketing and raising farm incomes. In Japan and Taipei,China, agricultural market information is a government service that receives regular government funding. In Japan, the Ministry of Agriculture, Forestry and Fisheries (MAFF) spends \$9.5 million every year maintaining and operating its information service for perishable foods alone (fruit and vegetables); large sums are also spent on other commodities. In Japan, ZEN-NOH, the national farmers' cooperative organization, operates an information service.

In Japan, enforcing auction-based transactions forms the basis for its market information system. The Central Wholesale Market Law of 1923

laid the foundation for the development of the wholesale market system in Japan, and the law mandated the use of public auctions to ensure fairness in transactions. Auction-determined prices would be fixed, all transactions would use these prices, and different prices could not be charged for different transaction volumes (preventing quantity discounts, for example). Although this law restricts the types of transactions that take place, the added benefit of impartiality is very important. Previous to the reform, most prices were negotiated in secret between sellers and buyers, and this sometimes prevented market information from becoming more widely known to other potential market participants.

MAFF provides daily market price information on fruits, vegetables, poultry, and meat at wholesale markets to the public. The data cover daily, semimonthly, monthly, and yearly information. The daily information covers price and total quantity handled at 29 sampled wholesale markets. Other than MAFF's reports, each wholesale market authority (city offices, in most cases) also publishes its own market reports. For example, the Sendai central wholesale market publishes prices and quantities of aquatic products, vegetables, and fruits on weekly, monthly, and yearly bases. The data are collected from wholesale traders, and all the information is sent to a data center in Tokyo.

ZEN-NOH provides producer-oriented information services to its members through a web portal. This web service offers information related to agricultural technology, fertilizer application standards, and daily price information for fruits and vegetables by product and market. The daily market information arrives in three waves. Information is relayed to mobile phones as well. Market information sent from ZEN-NOH comes from MAFF and other agencies. The information includes price trends and quantity of produce at each wholesale market. Three levels of price quotes are provided: high, medium, and low. Besides vegetables and fruits, information on livestock products is available. Transaction prices and quantities at each wholesale market are provided daily.

Major wholesale markets across Taipei, China are required to adopt computerized auction systems to improve data collection and facilitate efficient information transmission to market participants. These auction systems result in fair, efficient transactions, which benefit market participants. They also improve data collection and facilitate efficient information transmission to market participants. After data are collected in wholesale markets, information is not only released in the wholesale market but is also transferred to government departments and published

on relevant websites. Farmers can easily obtain transaction information through the internet by searching by product code.

In Taipei, China, such technologies were seen to overcome unfair practices such as underreporting arrivals, misstatements of transaction prices, and misreporting damages. The auction system helps to maintain openness and competitiveness in the transaction process, while agricultural pricing information provides precise market information based on actual transactions that can help market participants make informed decisions. For example, in the wholesale market in the city of Taipei, all arrivals and transactions are recorded electronically, and the resulting statistics are announced to the public immediately through television broadcasting or radio. The system not only provides market participants with information that serves as a basis for their decision making but also reduces prices paid to intermediaries and ensures that buyers and sellers are better aligned.

Cold Chain Technology

Findings from the study indicate that the governments' approaches to developing cold chain logistics differed widely among the economies studied. In the US, the government allowed the commercial market to drive the adoption of cold chain distribution. Japan and Taipei, China have both employed government-led programs to increase usage of cold chain technologies. Among the economies that promoted cold chain technology actively, government programs varied, ranging from direct measures (such as creating and issuing standards and providing incentives on capital investment) to indirect measures (such as funding research and education).

The US government provided significant support for research during the early years of cold chain technology establishment. Harvey W. Wiley, then chief of the Bureau of Chemistry of the United States Department of Agriculture, had long recognized the importance of understanding what constituted pure and safe food and drugs. Wiley created a new laboratory, the Food Research Laboratory, to develop scientific methods of food analysis. The lab's research on poultry and egg marketing from 1907 to 1919 provided the evidence needed to establish "an integrated, hygienic, refrigerated chain of poultry and egg producers, processors, and retailers that stretched from the farmer to the consumer." The lab developed efficient refrigerated systems for bringing chickens and eggs to market; refined existing cooling technologies; guided further development of refrigerated transportation, such as refrigerated boxcars; and set standards for judging the purity of poultry and eggs. The

scientific work enabled federal and state legislatures to set up and enforce standards of cold storage and establish a “comprehensive cold chain of refrigerated, sanitary processing, storage, and transportation facilities for poultry and eggs.” This enabled the emergence of a truly national cold chain for poultry and eggs in the US.

Market forces not only promoted research and development on refrigeration systems; they have also been the primary driver for the growth of cold chain technology distribution in the US. Two key drivers in the market that led to wide-scale adoption of cold chain technology were industry consolidation and vertical integration, which enabled large-scale operations and the economies of scale that made business investments in cold chain infrastructure possible. The US experience indicates that consolidation and technology penetration typically began with retail markets, propagating upstream in the supply chain to wholesalers and food processors. One of earlier waves of consolidation took place at the time of the Great Depression in the 1930s, when many of the small mom-and-pop retail stores that could not stay in business were absorbed into growing chain stores. The higher volume of products resulting from consolidation provided the financial rationale for enterprises to spend money on refrigerated storage and transportation and still be able to attain an operating profit. It was at this point that the use of large-scale equipment, such as 40-foot refrigerated containers (or reefers), started to grow rapidly. The consolidation of retail stores also substantially altered the competitive arena in the upstream of the value chain. The smaller number of larger retailers with greater purchasing power also led to the consolidation of the immediately upstream suppliers, which, in turn, could afford to invest in cold chain distribution to serve their retailer customers. This consolidation of the wholesalers and the intermediate players also led to the consolidation of the segment of the value chain further back to the manufacturers and processors, thereby resulting in the adoption of refrigeration technology across the supply chain.

In contrast to the US, where the government has taken a hands-free approach to developing cold chain distribution, Taipei, China and Japan offer examples in which the government intervened actively to promote use of cold chain technologies. For instance, in Taipei, China, cold chain transportation in the early 1970s consisted of normal-temperature trucks with quilts or polyethylene, as is the typical situation in the PRC today. In the 1980s, a small number of insulated trucks were used while some transporters were still using dry ice. It was only in the 1990s that refrigerated trucks with standard temperature control were employed (China Science and Technology Exchange Center, undated). Today, use of cold chain technologies, as measured by the proportion of possible foodstuffs that are

shipped using low-temperature storage, reached 80%–90% in Taipei, China (Government of Taipei, China 2010).

To address the challenges associated with temperature control during cold food transportation, Taipei, China's Department of Health stated in 1989 that, for loading and unloading cargo, the temperature must remain below 15°C in order to meet department standards. Throughout the transportation of frozen food, the standard requires temperatures below –18°C for frozen food and 7°C for cold food in order to achieve ideal conditions for distribution (Ting 2013).

To help the industry ensure the quality and safety of refrigerated food and provide a satisfying living environment, Taipei, China's Department of Health started an evaluation project among cold-food vending shops. In 2001, the evaluation was extended to logistics as well, with the purpose of diffusing key concepts in cold chain logistics (Modern Material Handling and Logistics, undated).

In Taipei, China, the government has also enacted initiatives to improve the cold chain by providing guidance for the logistics industry. To meet the demand for commodities logistics in the global market, in 2012, the Ministry of Economic Affairs asked the logistics industry to upgrade software and hardware, obtain experience in low-temperature services, and enter new markets. New initiatives include introducing of advanced cryogenic equipment; applying a cloud information platform, creating full traceability of fresh information-control mechanisms; and serving potential markets and creating business markets, especially in the PRC (Government of Taipei, China 2010).

Japan's per capita refrigerated warehouse capacity is among the highest in the world. As of 2008, it ranked the fourth-highest per urban resident, at 0.4 cubic meters per person (Salin 2010). A cold chain system is used widely across the supply chain, including immediately postharvest (precooling), transportation to the wholesale markets, storage at the markets, transportation to retailers, and retail market storage. The precooling of fruits and vegetable at producer areas started slowly around 1975 and reached wide-scale adoption throughout Japan around 1990. Refrigerated showcases are widely used by retail stores such as supermarkets. It is also common practice to handle fresh food products within the refrigeration temperature range in the retailers' distribution centers.

The Government of Japan had a major initiative to expand its cold chain infrastructure in 1965, when the Resources Council, Science

and Technology Agency made recommendations to modernize the comprehensive food supply chain system and called for construction of cold chain capacity, among other food distribution development efforts. After this announcement, the then Ministry of Agriculture and Forestry served as the central agency to implement the development of production and distribution facilities for vegetables, fruits, livestock, and seafood. Refrigerated transport and storage technology and precooling facilities entered a period of rapid development following this announcement.

In Japan, the government also used mandates to promote use of refrigeration at key distribution points. Starting in 2011, the Wholesale Market Act required central wholesale markets to meet certain standards.²¹ Specifically, it required about 70% of the wholesalers and 40% of intermediate wholesalers to install cold storage equipment (Distribution System Research Center 2013). Programs that provide government subsidies for installing cold chain equipment have also been made available. One of the programs under this initiative provides government subsidies to wholesalers that adopt cold chain technologies. Specifically, for enterprises that install cold chain equipment through lease terms, the government will provide half of the leasing costs (MAFF 2012).

These experiences suggest that government programs to promote cold chain usage tend to be implemented at key places of trade where the government already intervenes in operations, such as wholesale markets.

²¹ The Wholesale Market Act was enacted in 1923 and has since been modified several times. The law established central wholesale markets to make fresh food accessible to consumers.

CHAPTER 5

Policy Recommendations

We used the analysis presented in Chapters 2, 3, and 4—assessment of the current landscape of agricultural logistics system in the People’s Republic of China (PRC), business process analysis, and international experience—to identify numerous shortcomings in the current system, and opportunities for improvement. Although some economies and regions rely primarily on market forces to improve their agricultural logistics systems, our investigation of international experiences suggests that government, as well as private enterprise, can play a key role in reform when market players lack capacity and experience in, for example, standard setting, and market mechanisms are less mature than those in more developed economies. We prefer relying on market forces in lieu of government intervention to address the challenges in agricultural logistics in the PRC identified in the previous chapters. However, if those forces are not yet working as they should, we recognize that the government needs to act—as international experience has shown—to catalyze change. This appears to be particularly true for uniform packaging standards, but our observation applies broadly across the recommendations in this chapter.

This chapter outlines a series of recommended policy options for taking steps to promote efficiency improvements in agricultural logistics in the PRC. Although a full cost–benefit analysis of these policy options was beyond the scope of this study, we hope that the actions we describe here will be considered carefully and investigated further because many would ultimately require a careful study of the implementation approach and details. We structure the recommended policy options into two groups: first, recommendations that focus on improving the logistical flow in the agricultural product supply chain; and second, recommendations for enhancing the organization of market participants and logistics infrastructure.

The actions that focus on the logistical flow aim to improve two critical types of flows in the supply chain: product flow and information flow. Measures to improve the flows of products facilitate physical handling, storage, and transportation of products. Improving the flow of information entails making accurate, timely market data available to market participants.

Better market knowledge and information exchange will lead to more efficient transactions and a better functioning market for agricultural products. These two sets of measures would lead to improvements in key metrics such as spoilage rates, lead times, and total logistics costs. Together, they would lead to overall efficiency increases in the system. These policy actions are considered short to medium term and are given higher priority than others because they can improve the efficiency and safety of the logistics system more quickly than other policy actions can.

The second set of policy considerations refers to changing the way in which producers and distributors are organized and helping them develop their skills. It also includes investing in facility infrastructure to increase capacity and modernize facilities. These strategies could take much longer to implement successfully and might not necessarily result in immediate improvements in logistics performance. However, they will be key sources of improvements in productivity and safety for the PRC's traditional food system in the long term, and their implementation would further strengthen vertical coordination in the supply chain and enhance the market environment.

The short- to medium-term actions address three key areas of the logistics system discussed earlier: packaging standards, product grading and food safety, and market information systems. The long-term policy considerations address issues related to the scale of operations, cold chain technology, and logistics infrastructure in a broader sense.

Uniform Packaging Standards

Having uniform, standardized packaging for different agricultural products is expected to enhance vertical coordination throughout the agricultural logistics system and bring multiple benefits, including faster identification and processing of products and lower damage and loss rates.

Our international experience revealed that the market, rather than government, plays a key role in setting the standards. For example, the farmers' organizations and wholesale markets in collaboration worked out the specifications of the packaging and labeling and created an interoperable system of identifying and transacting the packaged products. However, in economies such as the PRC, where the government plays a large role in the operation of the economy and there is no strong presence of the organizations that represent the interest of the players (such as industry

associations), a market-based approach can face hurdles to developing uniform packaging standards, in which case government intervention to lead standardization efforts is better than the existing system, in which multiple factors, including government interference in the market, have led to difficulties in establishing standardized container sizes.

The following steps can be taken to improve the enforcement and implementation of the existing national product packaging standards:

- **Implement national packaging standards using the network of wholesale markets.** The PRC has a vast array of wholesale markets that serve as collection points in the traditional food system. Beginning with the largest and most strategically positioned wholesale markets, and focusing on products for which different packaging standards create the most problems, policy makers should start to require coordination and uniformity of packaging standards that comply with existing national regulations. Wholesale markets should refuse to accept products from sellers that are not packaged according to these standards, forcing market participants to adopt uniform packaging and labeling. Over time, coordination throughout the system would follow.

Key actors. Central government to issue legislation, and the provincial and local governments to enforce.

- **Use industry associations to develop and promote standard packaging.** Although farmers' associations can play a critical role in promoting standardized packaging (such as in Taipei, China), the PRC does not have centralized farmers' associations at the national level. This means that the government needs to look for other types of market participants to help develop and promote national standards. Subject-matter knowledge and experience that industry groups possess can be leveraged to develop and implement packaging standards. Industry associations that represent segments of the value chain can contribute to defining stakeholder requirements for packaging and promoting the use of packaging. Associations that specialize in subject matter can aid developing food packaging technologies and business processes.

Key actors. Central government to lead with policy; industry associations to implement.

- **Conduct information campaigns for farmers about proper packaging.** Beginning with the most important products, the government should provide farmers, traders, and wholesalers with detailed instructions about appropriate packaging methods. This education would improve farmers' understanding of the importance of proper packaging and labeling and speed up the adoption of uniform standards throughout the system. These information campaigns would have to be specific to different types of products and targeted at appropriate audiences to minimize costs. Although a few targeted information campaigns might be costly initially, over time, as information rapidly spreads through the system and packaging standards are widely adopted, they could lead to efficiency improvements.

Key actors. Provincial and local governments and industry associations.

- **Consolidate and clarify enforcement responsibilities.** The State Council should designate a single decision-making body to to enforce product packaging standards at each stage of the production and distribution process. Currently, various government bodies are responsible for supervising the implementation of many different food standards in the PRC, including the Ministry of Agriculture; the Ministry of Commerce; the Ministry of Health; the General Administration of Quality Supervision, Inspection and Quarantine; the State Administration for Industry and Commerce; and the Ministry of Environmental Protection. These government bodies are responsible for inspecting and enforcing packaging standards at different stages of the distribution process. Both the large number of agencies responsible and the absence of system-wide supervision create a lack of coherence in the enforcement system. A single body should monitor the performance of all points of the system, and its precise roles and responsibilities should be properly defined. In general, when many agencies are involved in regulating the same industry, there are problems of overlap, gaps, and contradictory regulations. A single regulatory body is generally considered more effective than multiple bodies (United States Government Accountability Office 2011). This single regulatory body would be a central government agency that consists of provincial and local governments that operate at different levels of jurisdiction.

Key actor. Central government.

Product Grading and Food Safety

A harmonized product grading system enables consumers to understand the quality of the products they purchase and leads to a better functioning, differentiated market for those products, which benefits producers and consumers together. In the absence of an effective system of food grading, labeling, and safety inspections, market participants can contaminate food and adulterate it, threatening public health. Although there are many ways to promote product grading and labeling, food safety standards can be a strong driver for value chain participants to adopt grading and labeling. Therefore, establishing and implementing food safety standards should be the basis for product grading and labeling programs.

The following steps should be taken to improve enforcement and implementation of the existing food quality and grading regulations:

- **Consolidate inspection responsibilities.** The State Council should consolidate responsibility for inspecting and grading food products in a single decision-making body. Right now, many different government agencies are responsible for inspecting, grading, and labeling food products, depending on the stage of the production and distribution process. As with the case of packaging standards, the division of responsibilities across different agencies creates a lack of uniformity and coherence in the inspection system, increasing the likelihood that adulteration and food safety breaches take place. A single agency should be responsible for supervising grading, labeling, and food safety inspections at every stage of the production and distribution process. This agency should be organized in a hierarchical manner, with offices at the national, provincial, and prefecture levels.

Key actor. Central government.

- **Expand safety inspection and grading along the supply chain.** Currently, food products are inspected and graded in the PRC only when they enter wholesale markets. However, many food safety concerns begin at the point of production, such as excessive pesticide use for certain fruits and vegetables. The system of inspection should try to reach beyond wholesale markets and into the first mile of the agricultural logistics process, so that if there are problems with grading or food safety, it is easier to determine where they originate and prevent them from spreading or reoccurring. Implementing this measure becomes much easier if there is a centralized collection and

distribution system, as exists in economies with farmers' organization. In the absence of such infrastructure in the PRC, where products are handled in small volumes, the actual extent of inspection should be carried out based on effective sample methods to keep the cost of inspection under control.

Key actors. Central government to issue legislation; provincial and local governments to enforce.

- **Strengthen traceability systems for food products.** Many of the food safety problems encountered in the PRC might have been avoided had a system been in place to trace tainted food back along the production chain. Producers that know that their food can be traced will be much less likely to violate food safety regulations. Moreover, such a system would allow the consumer to reward those that produce high-quality product via price premiums and, in turn, encourage the introduction of branded products. Although many markets in the PRC have already taken preliminary steps to develop and implement traceability systems for meat and vegetables, for many products, these systems are still primitive and are not national in scope. Without a fully functioning traceability system, it is difficult to identify products that do not comply with grading or food safety standards and trace them back to specific producers or brokers. For the most perishable and potentially dangerous agricultural products such as meat products, the government should subsidize the adoption of traceability systems, so that products can be traced back to their sources. This traceability system should also go hand in hand with the system of inspection, so that the inspectors themselves can be monitored in case there are problems with inspection equipment or ineffective monitoring that takes place.

Key actors. Central government to lead policy; provincial and local governments and industry associations to implement.

- **Encourage the media to publicize food safety infringement.** Independent media can play an important role in spreading information about public health concerns, and this can lead to important improvements in food safety as producers, consumers, and the governments respond to this information. Food safety outbreaks need to be caught and brought to the public's attention as soon as possible so that they can be contained and cause minimal harm to the population. When threatened by possible food safety infringements that could lead to reduced demand and lower profits, producers will respond naturally by improving food safety. Although the media alone cannot be relied on to reduce or prevent food safety problems, they

can play an enhancing role in nudging producers and policy makers into action.

Key actors. Central government; news media outlets.

- **Develop stronger legal measures for enforcing food safety.** Recent efforts at food safety legislation, such as the Food Safety Law of 2009, provide measures to punish local government officials if food safety infringements originate from within their jurisdictions. Although this is helpful, it does not go far enough in holding food production companies directly accountable for creating food safety problems in the first place (Ni and Zeng 2009). Producers or manufacturers of adulterated, spoiled, or unsafe food should be fined or taken to civil court, in which they should be held accountable for their malfeasance. With a stronger role for the media, widespread publicity of how perpetrators of food safety scandals are punished could encourage food producers and processors to take measures to prevent food safety outbreaks.

Key actors. Central government to issue legislation; provincial and local governments to enforce.

Market Information Systems

To increase market transparency and information visibility, and to build a market information system that is integral to improving the efficiency of the PRC's agricultural logistics system, we recommend the following actions:

- **Build the market information system by starting first with the largest and most important wholesale markets.** Many wholesale markets in the PRC currently collect and record information on market transactions and prices. Instead of using expensive market surveys, the government could reach out to these large markets and establish data feeds from the payment systems in these markets. After the transaction data from the largest markets have been harmonized, they can be summarized and disseminated directly to market participants, relying on existing communication technologies such as mobile phones. Over time, more markets can be added to the information system, and each new market can abide by the data requirements created during initial system establishment.

Key actors. Central government to issue legislation; the provincial and local governments to implement and enforce.

- **Enhance the functionalities of the market information system.**

Building the right functionalities in the market information system is essential for meeting the requirements of the end users of the system, including the farmers and traders. The following factors are considered important for a successful market information system:

- **Localized price data.** Farmers need to have access to market information that they can readily use. Often, market information at the national and regional levels, obtained by processing and assembling data from all over the PRC, could be useful to those working for central government agencies. However, it is of less value to farmers in the rural areas who might be receiving different prices for their products. Farmers are interested mainly in prices in local markets where they sell their goods. This requires building the capability to collect, process, and display market information at various levels, including remote areas, where there are wide regional price differences.
- **Demand forecasting.** Projecting market demand to guide farmers in their production planning is one of the most difficult tasks of a market information system. However, it can be among the most useful data for farmers, and building the capability to analyze supply and demand might be worth the investment. Investments in demand forecasting should start by distinguishing crops that continuously face marketing problems (i.e., production ought to be reduced) from those that have only occasional marketing problems or for which there is strong market demand. It should be noted that farmers are interested not only in current price information but also in marketing issues and news and demand forecasts.

Key actors. Central government to lead policy; industry associations to implement.

- **Enhance market information delivery to farmers.** Collecting market information is not enough. It must also be disseminated in an accessible, usable manner. Farmers are one of the key groups of users of market information, and they need to access this information easily. Farmers might not benefit from sophisticated systems if they are poorly managed or not designed for their needs. Many farmers in the PRC might not use common media such as radios or television sets, and many do not have access to a daily newspaper. At markets, sometimes farmers can be too preoccupied with the actual transaction to pay much attention to bulletin boards or radio broadcasts. Previous

attempts by central and local governments demonstrated success in using mobile phones to provide easy access to not only price data but also information on new agricultural technologies, product information, and agriculture policies.²² Although investing in infrastructure (such as mobile network and phones) could be costly and will require detailed feasibility studies and cost–benefit analyses to determine the optimal approach, the government can develop programs to disseminate the market data to the farmers over existing media.

Key actors. All levels of government.

- **Incentivize market participants to create a central, unified electronic marketplace.** A centralized, integrated market information system becomes the basis for the electronic marketplaces that establish networks of trading partners across regions and connect them together. Using electronic marketplaces can help producers connect to buyers beyond their traditional reach. Electronic mechanisms would allow products to be collected and sent directly to the wholesale markets in consumption areas, thereby bypassing intermediate stopping points. As long as farmers can consolidate their products and transport them in volumes (such as by using farmers' organizations), the total cost of delivery to end consumers will be reduced. This will shorten lead times, keep products fresh longer, and reduce spoilage. This provides advantages over the traditional model of moving products through multiple stages of wholesale markets.

Key actors. Central government to lead policy; industry associations to implement.

- **Designate a single government agency to be responsible for system construction and management.** A single government agency managing the information system enables system and data standardization; simplifies day-to-day data collection, data release

²² Includes mandates by the Ministry of Industry and Information Technology of the People's Republic of China to implement the "telecommunication village connected" project aimed at establishing universal telephone and mobile phone services to nearly 70,000 administrative villages (General Office of the State Council of the People's Republic of China 2005); Tianfu Agriculture Information Network in Sichuan Province to distribute agriculture-related information to farmers via mobile phones, telephones, and the internet in 2003 (Li 2007); and the New Agriculture Access information platform that was launched in January 2011, which used mobile phone text messages for free access and publishing of information on agricultural market information (Academy of Social Science of Sichuan 2012).

procedures, and analysis operations; and reduces the total system cost. In both Japan and Taipei, China, the agencies in charge of the market information systems are affiliated with the equivalent of the PRC's MOA. The single agency in charge of the market information system can provide data requested by other agencies for their own specific purposes. Under this unified management structure, data integrity and accuracy would be ensured across all government agencies.

Key actor. Central government.

Long-Term Policy Considerations

We provide a number of long-term policy-making considerations for addressing organizational and infrastructure constraints on improving efficiency for agricultural logistics in the PRC. We address three areas discussed in previous sections: increasing the scale of operations in production, wholesale market integration, and logistics facilities and cold chain technology. Organizational and infrastructure improvements discussed here can take a long time to implement, and a more detailed policy analysis could be required to understand the specific actions to be taken.

Increasing the Scale of Operation in Production

To modernize agricultural logistics, the PRC needs to move from the current state of working with small volumes of farm products and increase economies of scale in production and distribution. Farmers' cooperatives can play a key role in increasing economies of scale in production logistics through better production and marketing practices. Farm products can be handled and transacted in much larger volumes, and producers will be able to exercise greater bargaining power, thereby reducing the gap between producer and consumer prices. The larger network of farmers could become a vehicle through which the government could quickly implement policies and standards. In addition, the larger scale of operation allows investment in infrastructure, such as refrigerated warehouses, in regions and for types of products for which temperature control is critical for the quality and shelf life of goods.

As the international experiences that we reviewed in Chapter 4 demonstrate, there are many different ways to increase the size and scale of farms, including consolidating existing plots of land; increasing the

presence and effectiveness of agricultural cooperatives; or promoting more modern vertical distribution formats (e.g., direct distribution from farms to retailers, electronic commerce formats).

For the PRC, we describe three different approaches for potentially increasing the scale of production operation: consolidating farmers' cooperatives, building strong third-party logistics enterprises that can consolidate supply and marketing activities, and vertically integrating producers with retailers:

- **Consolidate farmers' cooperatives.** One approach to improving the scale of operations in production would be to consolidate the existing network of farmers' cooperatives. The government of the PRC could promote and guide integration among farmers' cooperatives at the local and regional levels to form larger agricultural organizations that can organize larger-scale operations, including purchasing, production, marketing, and logistics activities. Smallholder farmers would then enjoy greater market power (more favorable input and output prices),²³ lower transaction costs, and greater efficiency. We recommend that the government of the PRC create a system of providing various incentives to farmers' cooperatives that reach a certain size of operation. Such measures would motivate the small cooperatives to coalesce and form bigger organizations. An additional advantage that larger groups of producers might also have is a stronger incentive to comply with regulations and to enforce voluntary food safety standards, in order to preserve their brand images.

Key actors. All levels of government.

- **Encourage the development of third-party logistics.** Increasing the scale of logistics operations can be externally driven, by building large-scale enterprises that can help consolidate the supply and marketing functions of the farmers' cooperatives. The government of the PRC should encourage the development of third-party logistics enterprises that perform professional marketing and supply services for farmers and the cooperatives. Government should provide support for these organizations to also offer a wide variety of agribusiness services to producers, including food processing and packaging, brand cultivation, finance and information services, agricultural extension, and farming technology education. Enterprises that reach a certain scale of

²³ More favorable prices for one group of traders might be less favorable for others.

operation can build logistics facilities and production centers, such as refrigerated warehouses for precooling and storage. International studies have shown that farmers' associations offer many of these services. However, in the absence of an extensive and large-scale farmers' organization in the PRC, logistics enterprises can perform many of the services.

Key actors. Central government to lead policy; industry associations and private enterprise to implement.

- **Encourage further vertical coordination.** Vertical coordination between production and retailing can lead to extensive efficiency improvements, leading to lower food prices and less waste and spoilage. Many different food processors and retailers are attempting to achieve this through vertical integration (acquisition of actors in the value chain) in the PRC's agricultural logistics system, but the government could adopt several measures to expand and enhance the activity that is currently taking place. These measures include helping large-scale retailers connect with small-scale farmers, enhancing contracts laws and dispute-resolution mechanisms in order to make sure that contracts between retailers and producers are fair and abided by, encouraging large-scale retailers to work more closely with the existing network of wholesale markets to ensure on-time delivery of products, and possibly subsidizing large-scale retailers for their efforts.

Key actors. Central government to lead policy; industry associations and private enterprise to implement.

Wholesale Market Integration

Having central oversight over wholesale markets can result in stable, efficient distribution of agricultural products in the PRC. Creating a centralized regulatory framework can address two elements of wholesale markets: establishment and operation. As seen in the Japan and Taipei, China examples, governments can exert influence over the establishment of wholesale markets by setting up and using a governance structure. Government can also supervise the operation of wholesale markets to ensure that they function properly and achieve safety and efficiency in the distribution of agricultural products:

- **Establish a governance structure for wholesale markets.** Although the government will likely not own and operate the wholesale markets,

a governing body that determines the process by which a regulator creates rules and actions for wholesale markets should be set up. The governance structure should specify the government authority that will have supervision over the wholesale markets, with a hierarchical structure consistent with that of the tiered system of wholesale markets.

Key actor. Central government.

- **Invest in the infrastructure of wholesale markets.** Government can speed up the integration of wholesale markets by subsidizing the construction or upgrading of wholesale market infrastructure, including facilities and capital equipment. In addition to these one-time investments, providing subsidies for the transaction fees that wholesale markets charge market participants can increase the volume of goods sold through the wholesale markets. Government investment can also include setting up temperature-controlled warehouses, especially targeting the goods that are sold on long-distance routes.

Key actors. Provincial and local governments.

Logistics Facilities and Cold Chain Technologies

We propose a method of promoting cold chain logistics in the PRC by focusing on key places of trade in which the government already intervenes in operations—namely, wholesale markets. Moreover, based on the business process analysis in Chapter 3, wholesale markets also account for a significant portion of the total delivery lead time for agricultural products. Therefore, these locations can be a good starting point for building refrigeration capabilities to lengthen the shelf life of fresh produce and reduce spoilage in the system. Maintaining longer shelf life also increases food safety. Although the PRC might not be able to build the cold chain for all agricultural products in a short time, it can start to build the refrigeration capacities selectively at segments in the value chain in which products tend to reside the longest. Policy actions that the PRC government can consider for developing the logistics infrastructure in general include:

- **Increase the refrigerated storage capacity at wholesale markets.** The government can require that a certain percentage of the storage capacity at wholesale markets be installed with refrigeration capacity. This program should focus on wholesale markets at strategic locations that transact short-shelf life products that are stored at large volumes

and travel great distances. This program should be implemented in multiple stages, increasing the storage capacity at wholesale markets over time. Government can also provide subsidies for building cold storage. If the investment is made at targeted segments of the perishable value chain, it can significantly increase the adoption of cold chain technology that leads to higher food quality and lower spoilage in the system (Appendix 3).

Key actors. Provincial and local governments.

- **Support long-distance, high-volume agricultural product transportation modes.** Government should encourage national railway transportation enterprises to engage in developing long-distance agricultural logistics transportation infrastructure, including trains designed specifically for agricultural product containers. The government could focus on connecting major production centers to high-consumption cities for delivering high value-added fresh agricultural products. However, railway is a relatively slow transportation system and might not be suitable for products with short shelf life, such as perishable goods, but it can be considered for staple products and nonperishables.

Key actors. All levels of government.

APPENDIX 1: MARKET INFORMATION SYSTEMS AND AGRICULTURAL MARKETS

In this appendix, we review the theoretical and empirical literature on how market information systems affect agricultural markets.

Theory

Some of the most important theories in economics about markets require that agents have accurate price information. A simple but powerful theorem, the law of one price, states that the price of a good in any two markets cannot differ by more than the cost of transport between them. If agents had knowledge of two markets with greater price differences, they would earn profits through arbitrage. Those agents would purchase at the lower-priced market and sell at the higher-priced market until price differences equaled the cost of trade. By connecting the excess supply in one market and the excess demand in another, price differences will fall, and total welfare (between producers and consumers) will increase.

Crucially, the law of one price requires that agents be able to observe prices in all markets. If price information is not common knowledge, and the costs of obtaining this information are high, price differences can persist between markets, leading to inefficiency in which there is excess supply in some markets and excess demand in others. Intuitively, if search costs are large enough, arbitrage between markets might not be profitable, leading to persistent differences in prices. Several researchers, under fairly general settings, have shown that reducing search costs leads to efficient arbitrage, which increases total social welfare, generally by reducing excess supply in some markets and excess demand in others (Jensen 2010).

Another powerful theorem, the first fundamental theorem of welfare economics, states that competitive market equilibriums are efficient and optimal, in the sense that the market allocates goods to consumers and income to producers in a way that, under a different allocation, no indi-

vidual can be made better off without reducing the welfare of others.¹ This theorem of welfare economics refers to allocative efficiency, the extent to which the market mechanism allocates the economy's resources, which include goods produced and consumed and the labor and capital that produce those goods in an efficient manner. This theorem also requires common knowledge about prices, but, in practice, the information available to agents is often costly to obtain or is incomplete (Stigler 1961). If agents cannot perfectly observe prices or if obtaining information about products is costly, the decisions made in markets might not lead to efficient outcomes.

Note that, even apart from gains to allocative efficiency, better information can affect the distribution of welfare between farmers, traders, and consumers. In some markets, search costs can be so large that relatively few traders arbitrage away price differences. Instead of completely reducing those price differences to the cost of transport, those traders could extract profits, or rents, in a monopoly or monopsony arrangement. In such a setting, providing information about price differences could increase the entry of traders, which would reduce their market power and either raise prices paid to farmers, reduce consumer prices, or both. Both the magnitude of the effect that information improvements can have on allocative efficiency and the direction of effects on equity or the distribution of welfare are empirical questions.

Evidence

Several researchers have studied how providing information to agents in agricultural markets leads to different market outcomes. The expansion of mobile phones in developing economies, which allow people to communicate with one another about market prices, provides a nice experiment for analyzing the effect that information improvements have on markets. Jensen (2007) studied how mobile phones affected the performance of fish markets in the Indian state of Kerala, a coastal state with a large fishing industry. Between 1997 and 2001, mobile phone service was expanded throughout Kerala. According to the study, before mobile phones were introduced, there were substantial price differences between regional fish markets, and these differences were often larger than transport costs. On the same day in markets in different locations, some markets contained buyers who would walk away because the price they faced was too high,

¹ This definition of optimality is known as Pareto optimality in economics literature.

while, in other markets, sellers would dump their catches, unable to sell because there were no buyers.

Using survey data, Jensen (2007) showed that the adoption of mobile phones by fishers and wholesalers led to a substantial reduction in price differences across markets. Although the price of fish tended to fall by around 4%, benefiting consumers, producers were better off because market information enabled them to sell to the right markets, increasing the amount they sold and eliminating waste.

Another study on the impact of mobile phones is much larger in scope and set in a different context. Aker (2010) examined the impact that the introduction of mobile phones had on grain markets in Niger. The author found that mobile phones led to a 10%–16% reduction in price dispersion, and that most of the impact was due to changes in trading behavior. Traders with mobile phones were better able to search for sales opportunities across more markets, and this reduced the variability in consumer prices.

One reason that Jensen (2007) might have found that information improvements had such large effects on fish markets is that fish are highly perishable. Many other commodities can be stored, which could dampen the effects of information because it allows suppliers to wait to sell their products until buyers are present or prices are favorable. Reporting on a follow-up study, Aker and Fafchamps (2015) examined the differences in effects across different types of goods. The authors found that, in Niger, mobile phones had larger effects on cowpeas, which are perishable, than on millet, which is more durable. This suggests that information might have larger effects on nondurable goods.

A particular feature of these studies is that they focus on the use of mobile phones to obtain information, but there are other ways of disseminating market information. Svensson and Yanagizawa (2009) reported on a study of the effect that radio broadcasts of market prices had in Uganda in which the authors found that farmers who received this information achieved a 15% higher farm-gate price for maize and led to a 55% increase in farmers' crop revenues. Goyal (2010) reported on a study in which the author found that the introduction of e-choupals, or internet kiosks, raised soybean prices, increased soybean production by 19%, and increased farmers' net profits by 33%. However, most of these effects came through redistributing income away from traders, so the overall welfare effects of such use of market information are not clear.

APPENDIX 2: BENCHMARKING COSTS FOR INTERMEDIARIES

An agricultural intermediary, such as a specialty food broker, purchases some quantity of agricultural output, Q , at an origin price, P . The intermediary then transports those products to the next distribution center and sells them at the prevailing destination price, P^* . Because food products are perishable, some fraction of the product spoils in transit. Let τ denote the spoilage rate, so that the total quantity delivered at the destination is given by

$$Q^* = Q(1 - \tau). \quad \text{B.1}$$

Let c denote the marginal, per unit cost of shipping the product from the origin to the destination location. This cost incorporates a variety of different factors outside of the model, including the labor cost paid to truck drivers and product handlers, the marginal cost of renting or using capital equipment, fuel costs paid for shipping, and fees paid at the market for shipping and handling. Although we collected data on some portions of this cost, many aspects are still not observed.

Given this setup, we can write the total profits of the intermediary from moving goods from the origin to the destination as follows:

$$\pi = P^*Q^* - PQ - cQ.$$

Substituting in Equation B.1 and rearranging terms, we can obtain the profit per unit of goods shipped as follows:

$$\frac{\pi}{Q} = P^*(1 - \tau) - P - c.$$

If the market for intermediaries were perfectly competitive, free entry would drive this per-unit profit to 0. That would mean that destination prices would have to be given by the following:

$$P^* = \frac{P + c}{(1 - \tau)}. \quad \text{B.2}$$

This formula allows us to back out the share of costs in price differences:

$$\theta_c^{\text{def}} \frac{c}{P^* - P} = \frac{P^*(1 - \tau) - P}{P^* - P}. \quad \text{B.3}$$

We can use data on origin prices, P , destination prices, P^* , and spoilage rates, τ to calculate θ_c .

Note that, if intermediaries are charging markups and exercising market power in the transactions that take place, we will be overstating the share of price differences that are due explicitly to costs. To see this, suppose that equilibrium destination prices are given by Equation B.2 plus some positive markup, M , where, without loss of generality, we assume that the markup is discounted by the spoilage rate:

$$P^{**} = \frac{P + c}{(1 - \tau)} + M.$$

Using this expression, we can solve for the numerator in Equation B.3 and substitute to obtain the following:

$$\theta_c = \frac{c + M(1 - \tau)}{P^{**} - P}. \quad \text{B.4}$$

This suggests that, if intermediaries charge markups, the cost share that we calculate will reflect both the actual costs of transporting and those markups. More careful research on intermediary costs would let us understand how much of price differences were really due to markups and not transport costs, but, given the large number of intermediaries in the market and their low barriers to entry, we presume that markups are small.

APPENDIX 3: COLD CHAIN TECHNOLOGY DEVELOPMENT FOR STAPLES VALUE CHAIN IN INDIA

The international experience study described in this report focused on the advanced economies that achieved modernization of their agricultural logistics system. We selected three comparators to understand various policy approaches and lessons learned. However, developing economies have also implemented successful government-sponsored programs that addressed challenges similar to those that the People's Republic of China (PRC) faces today in agricultural logistics. This appendix discusses, in particular, how India has come to transform the domestic potato value chain by building and using a large number of refrigerated warehouses.

India is an agrarian economy in which agriculture accounted for approximately 18% of its gross domestic product (GDP) in 2013 (Statista 2015). After the PRC, India is the world's largest producer of fruit and vegetables and produces a significant amount of meat and poultry. India spends 13%–14% of its GDP on logistics, a percentage that is substantially higher than in developed economies and is higher than that in Brazil, the Russian Federation, or the PRC (Sen Gupta 2012).

Despite the high logistics cost, India still faces high spoilage rates for fruits and vegetables, much like the PRC does. According to the Food and Agriculture Organization of the United Nations' estimates, about 40% of India's fresh fruit and vegetables—worth an annual \$8.3 billion—perish before reaching consumers. The fresh produce on long-distance transportation is rarely cooled or shaded but rather subjected to the open air, creating high rates of spoilage (Kazmin 2014). India wastes more fruit and vegetables than any other food product in India, and inadequate storage and transportation and inefficient handling cause most of the waste.

However, there is much to learn from India's experience of having transformed the logistics for one of the most important food staples in India—potatoes. India has been able to build a vast network of cold storage facilities (CSFs) in its potato value chain. Although CSFs are available for just 10% of India's perishable produce, according to an Asian Development Bank (ADB) report, two-thirds of the potatoes sold at some of the major

consumption areas, including Delhi and Dhaka, had been cold stored (Reardon et al. 2012). Three-quarters of the CSFs are used to store only potatoes, a food staple that requires careful handling.

There has been a rapid increase of modern potato CSFs following massive investments in the 1990s and 2000s. Farmers, including even the small-scale producers, quickly switched from their traditional storage methods to cold storage. The barrier to accessing CSFs has been low for farmers, so adoption took off quite rapidly. The key business benefit for farmers using CSFs is the ability to greatly increase the potatoes' shelf lives and sell the potatoes many months after harvest, reducing the fluctuation in potato sales across seasons. Farmers thus have gained significant price advantages over storing. Consumers benefited too, by having the advantage of access to potatoes throughout the year. Use of storage also resulted in less spoilage in the system.

Government played an integral part in driving the adoption of CSFs in India. Direct government subsidies, combined with indirect government support for the infrastructure crucial to the establishment and operation of CSFs, such as road improvement and installation of energy grids, have driven much of the increase in scale and modernization of the cold chain in India. The Government of India has undertaken several initiatives to promote investment in cold storage infrastructure. The government's approval of 51% foreign direct investment in multibrand retail has been seen to provide impetus to investment in the cold storage market. Multibrand retail channels in India are expected to strengthen the cold chain infrastructure with the introduction of advanced technologies and robust distribution channels that multinational companies follow in other parts of the world. Government agencies, such as the Agricultural and Processed Food Products Export Development Authority and the National Horticulture Board, were set up to help provide financial assistance (Emerson Climate Technologies 2013).

CSFs in India also changed the way in which trading is conducted. Sellers and buyers shifted from using the old wholesale market system and conducted transactions at the CSFs. Cold storage was replacing the wholesale market. CSFs in Agra, for example, had taken on a major role of facilitating trade, so they brought the key actors in the value chain—rural traders, Agra-based wholesalers, Delhi wholesalers, and traders from other states—to compete at the CSFs as the venue for most trade (Reardon et al. 2012).

The CSFs were used for a variety of reasons. Farmers apparently cited storage of their crops as the topmost reason for using the CSFs. In addition,

the farmers used CSFs for opportunities to meet with the buyers who were willing to offer good prices. Other reasons included access to advances and credit and low cost and proximity of the CSFs. All farmers indicated that they would have used the CSFs even if the potatoes had been damaged during storage, noting the significance that the CSF has come to play in their business. The CSFs also provided access to new sources of extension and seed potato in India. In 1999, 22% of the farmers reported that they used CSFs as their main potato and seed suppliers, whereas, in 2009, the statistics rose to 64% of the farmers (Reardon et al. 2012).

Although the survey conducted for the ADB report told of success stories of CSF adoption in India, it revealed that the experience in the PRC differed greatly. It reported that

While the PRC government had a program to finance and encourage building of storage, the program had very little impact, given that most of the farmers who built storage did so without subsidy. The mainly on-farm or near-farm Gansu storages were built in the early 1990s. Only 5% of the farmers reported getting subsidies to build storage facilities (at a potential subsidy rate of 20%). Only 2.8% of the farmers got a loan and extension advice on storage from the government to build their storage unit. (Reardon et al. 2012)

It is speculated that the reason the modern storage facilities were not built in the PRC was the government's limited implementation of the program and farmer access to it. The state governments in India were much more active with investment and had subsidized the construction of CSFs and had invested heavily in power grids. Also, differences in the availability of sourcing potatoes might have contributed to the low adoption rate of CSFs in the PRC. For example, traders in Beijing had the choice of sourcing the potatoes from several provinces and thus were less subject to crop seasonality. In addition, whereas, in potato production zones in India the traders specialized mainly in potato, potatoes were only one of several cash crops in the production zone studied in the PRC. Having substitute food products reduced the incentives for farmers to store (Reardon et al. 2012).

The potato value chain experience in India tells us that active government investment in the form of subsidizing CSFs could significantly increase the use of cold chain technology and bring about many benefits, including high product quality, improved food security, greater economic benefits to the farmer and consumers, and less spoilage in the system. Much like the investment worked more effectively in certain trade zones than in others in the potato value chain, cold chain technology development in the perish-

able value chain also needs to be conducted in targeted segments of the value chain (such as nodes in the value chain in which the dwelling or storage time for the perishables is the longest) to maximize the return on investment. Other factors also need to be considered, such as substitutability of the product, as seen in the potato CSF case study in the PRC, in providing support for cold chain technology.

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* ADB recognizes “China” as the People’s Republic of China and “Taipei” as Taipei, China.

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Improving Logistics for Perishable Agricultural Products in the People's Republic of China

This report presents policy recommendations that would help modernize agricultural logistics for perishable products in the People's Republic of China. By assessing agricultural logistics systems in the People's Republic of China and other economies that have modernized their agricultural logistics, the study team presents short- to medium-term policy measures for enhancing food labeling, packaging, grading, and physical handling of products. Long-term measures include changing the way the producers and distributors are organized to facilitate a larger scale of operations and infrastructure development.

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